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Aggregate and Soil Proficiency Sample Testing Program for 2005

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Aggregate and Soil Proficiency Sample Testing Program for 2005

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Abstract

The Materials Engineering and Research Office, Soils and Aggregates Section, runs a proficiency sample testing program each year to provide a means for participating laboratories to see if they are performing satisfactorily. We also conduct a sample-testing program along with our annual proficiency program, for the tests related to Superpave consensus properties of aggregates.

The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating laboratories starting in June and they report their results for the aggregate and soil proficiency sample tests starting in the early part of August. A preliminary report issued in mid September allows the_laboratories to examine their procedures or equipment and correct any problems that may have occurred.

This is the final report for both, the Aggregate and Soil Proficiency Samples and Superpave Consensus Property Testing for 2005. This year there were two hundred and nine laboratories participating from the private and public sector in the Aggregate and Soil Proficiency Sample Testing Program. Fifty-two laboratories from the private sector and MTO Downsview laboratory reported results for the Superpave consensus property tests.

Results of the 2005 Proficiency Sample Program are found to be consistent with the results reported in the last three years but in some of the tests, the variations show noticeable improvements compared to previous years' results. Although there is noticeable improvement in results, strong laboratory biases still remain in many of the test procedures. The variations in the results for consensus property testing program are comparable to the values published in ASTM precision statements, except for the uncompacted void content test, where there is a need for further improvement.

Key Words Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave

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Table of Contents

Executive Summary iv
1. Introduction 1
2. Test Results 3
2.1 TABLE OF TEST RESULTS 3
2.2 SCATTER DIAGRAMS 4
2.3 OUTLIERS 10
3. Discussion 11
3.1 NOTES ON MATERIAL SOURCES 11
3.2 NOTES ON SAMPLE PREPARATION 11
3.3 NOTES ON INDIVIDUAL TESTS 12
3.4 PROFICIENCY SAMPLE TESTS 12
3.4.1 Wash Pass 75 µm (Coarse Aggregate) – Test No. 1 12
3.4.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6 13
3.4.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8 13
3.4.4 Relative Density (Coarse Aggregate) - Test No. 9 and 14
Absorption (Coarse Aggregate) – Test No. 10 14
3.4.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11 14
3.4.6 Percent Crushed Particles – Test No. 12 and 14
Percent Cemented Particles – Test No. 7 14
3.4.7 Percent Flat and Elongated Particles – Test No. 13 15
3.4.8 Petrographic Number (Concrete) – Test No. 14 15
3.4.9 Petrographic Analysis (Fine Aggregate) 16
3.4.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16 17
3.4.11 Freeze-Thaw Loss – Test No. 17 17
3.4.12 Sieve Analysis (Fine Aggregate) – Test No. 20-25 18
3.4.13 Relative Density (Fine Aggregate) – Test No. 27 and 18
Absorption (Fine Aggregate) – Test No. 28 18
3.4.14 Magnesium Sulphate Soundness (Fine Aggregate) – Test No. 29 19
3.4.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30 19
3.4.16 Moisture-Density Relationship (One-Point Method) – Test Nos. 31-33 20
3.4.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34 20
3.4.18 Particle Analysis of Soil – Test Nos. 40-45 20
3.4.19 Atterberg Limits of Soil – Test Nos. 46-48 21
3.4.20 Specific Gravity of Soils – Test No. 49 21
3.5 SUPERPAVE CONSENSUS PROPERTY TESTS 22
3.5.1 Uncompacted Void Content (FA) – Test No. 95 22
3.5.2 Sand Equivalent Value of Fine Aggregate – Test No. 96 22
3.5.3 Percent of Fractured Particles in Coarse Aggregate – Test No. 97 23
3.5.4 Percent Flat and Elongated Particles in Coarse Aggregate – Test No. 99 23
4. Laboratory Rating System 24
5. Conclusions 27
6. Recommendations 28
7. Acknowledgments 29
References 30

Appendix A: Glossary of Terms **31**
Appendix B1: List of Participants **33**
Appendix B2: List of Participants **46**
Appendix C: Multi-Laboratory Precision **49**
Appendix D1: Scatter Diagrams **55**
Appendix D2: Scatter Diagrams **93**
Appendix E1: Production Laboratory Ratings **97**
Appendix E2: Full Service Aggregate Laboratory Ratings **102**
Appendix E3: Soil Laboratory Ratings **104**
Appendix E4: Superpave Laboratory Ratings **105**

List of Tables

Table 1. Summary of Results for Laboratory 47 5
Table 2. Summary of Results for Laboratory 47 6
Table 3. Summary of Results for Laboratory 47 7
Table 4. Summary of Results for Laboratory 47 8

List of Figures

Figure 1. Examples of Scatter Diagrams 9
Figure 2. Fine Aggregate Petrographic Examination Scatter Digrams 17
Figure 3. Laboratory Ratings 25
Figure 4. Superpave Laboratory Ratings 26

Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office, runs an annual proficiency sample-testing program for aggregate and soil tests. This provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected by the Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in June. The laboratories report their results in August. A preliminary report issued in mid September, gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may have occurred. A final report is issued after analysis of the data has been completed.

In addition to our annual correlation program, the Soils and Aggregates Section is also conducting a proficiency sample-testing program for the tests related to Superpave Aggregate Consensus properties. This is conducted along with the MTO Aggregate and Soil Proficiency Sample Testing Program. The participants in consensus property tests are requested to perform four tests on the same aggregates that are supplied for the annual proficiency program. The laboratories report their results for this program in early October.

This is the final report for the 2005 MTO Aggregate and Soil Proficiency Sample Testing and the Superpave Aggregate Consensus Property Testing Programs. This year, there were two hundred and nine (209) laboratories from the private and public sector participating in the Aggregate and Soil Proficiency Sample Testing Program. Of these, one hundred and forty-seven were aggregate producer's and road builder's Quality Control (QC) Laboratories. The remainder were engineering testing consultants and owners laboratories. Participation in this program is required by the contract documents if contractors QC process is to be acceptable to MTO. In general, these laboratories are conducting particle size analysis, wash pass 75 µm, percent crushed particles, percent asphalt coated particles, and density tests for granular base and sub-base aggregates.

Fifty-two laboratories from the private sector reported results for the Superpave Aggregate Consensus Property Testing Program in 2005. The laboratories that participate in this program conduct uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent of fractured particles in coarse aggregate, and flat particles, elongated particles, or flat and elongated particles in coarse aggregate tests in accordance with the ASTM/AASHTO test methods.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating for each category of tests. This rating system has acted as an incentive for laboratories to improve their performance.

Results of the 2005 Proficiency Sample Program are more or less consistent with results from previous years and in some of these tests, the results show noticeable improvements compared to previous years' results. Particularly, sieve analysis, amount of asphalt coated particles, magnesium sulphate soundness (coarse & fine), and Micro-Deval (coarse & fine) show improvements over previous years. This is likely due, in part, to the laboratory improvements brought about by the Canadian Council of Independent Laboratories (CCIL) lab inspection program, for the Aggregate Laboratories. Although there is noticeable improvement in the precision of most of the test methods compared to previous years, strong laboratory biases still remain in some of the test methods. The variations in soil test results are consistent with the values reported in the previous four years of study, but the scatter plots show a strong laboratory bias.

The number of participants in the Superpave aggregate consensus property testing program has risen from twenty in 2002 to fifty-three in 2005. Most of the laboratories who, participated in the 2005 Superpave aggregate tests have now gained experience with these test procedures. The variations for all of the tests are comparable to the values published in ASTM precision statements, except for the uncompacted void content of fine aggregate, where there is need for further improvement. The scatter diagrams for all four tests show strong laboratory biases.

The Soils and Aggregates Section, continues to carry out the on-site inspection of soil-testing laboratories in an effort to improve the quality of testing services provided to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted by MTO must request a re-inspection whenever the technician(s) or equipment changes. To date, thirty-seven laboratories have been inspected, of which thirty-two laboratories have been approved to do testing of soils for MTO work.

1. Introduction

This is the final report of an annual inter-laboratory testing program organised by MTO for aggregate and soil test methods. It is primarily intended to provide a means for laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality control and quality assurance testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested parties should refer to ASTM C670[2], C802[3], E177[4] and E178[5] for further information on inter-laboratory testing programs.

There were a total of two hundred and nine laboratories participating in the Aggregate and Soil Proficiency Sample Testing Program, conducted in the summer of 2005. The participants were also asked to submit results for Superpave aggregate consensus property tests, if they were equipped to perform those tests. Fifty-three laboratories, up from twenty in 2002, submitted results for the tests related to the consensus properties. Participants in both testing programs included the MTO laboratory, the remainder being from the private sector (contractors, aggregate producers and engineering consultants) and municipalities. Samples were delivered to laboratories in June. A preliminary report for Proficiency Sample Testing Program was issued in mid September. This document is the final report for both programs.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

A new computer program was developed in 2002 to handle the computation and presentation of test data. For details of the program refer to the User's Manual (MERO Report No. 013) by Vasavithasan and Rutter, 2004.

The computer program has two statistical methods, namely the Critical Value Method and the Iterative (Jack Knife) Technique, to detect outlying observations or outliers in a set of data. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers but the MTO study follows the Critical Value Method recommended in Section 4 of ASTM E 178. The critical value method and iterative techniques are based on two different statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data.

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[1] Laboratories must also be inspected and recognised by the Canadian Council of Independent Laboratories (CCIL).

[2] ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.

[3] ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.

[4] ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.

[5] ASTM E178 Practice for Dealing with Outlying Observations.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E 178, Table 1 are limited to 147 observations, but over 200 laboratories participate in our annual Proficiency Sample Testing Program. The critical values that are being used for the MTO study were calculated at five percent significance level (Grubb's test) based on Grubbs (1969 and 1972) recommendations for identifying outliers. The Jack Knife method recommended by Manchester (1979) is used where the strict application of the critical value method tends to include results that may not stand the best chance of representing the testing performed in conformance with each of the test methods.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample, for all laboratories performing the test, after removal of outliers and/or invalid test data.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized deviate} = \frac{\left(X_i - \overline{X}\right)}{s}$$

If the test result is less than the mean, the standardized deviate is negative, and if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data or may be the result of gross deviation from the prescribed experimental procedure, calculation errors or errors in reporting data. The outlier criteria employed for exclusion of test results from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, *e.g.* sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.05) on the horizontal axis, against its test value for the second sample (2.05) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal cross hairs on the plots represent the mean values for all the results on the first sample (1.05) and the second sample (2.05), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 10, 2005

COARSE AGGREGATE REFERENCE SAMPLES 1.05 & 2.05

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.05	2.05	1	2	1	2	1	2
LS-601 Wash Pass 75 μm (Coarse Aggr.)	1.200	1.100	1.186	1.165	0.063	-0.254	5	-5
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	92.400	91.400	92.767	91.772	-0.328	-0.328	-5	-5
Percent Passing 16.0 mm	84.400	81.800	84.618	82.964	-0.170	-0.806	-5	-5
Percent Passing 13.2 mm	77.800	74.400	77.500	75.399	0.208	-0.679	5	-5
Percent Passing 9.5 mm	65.900	63.100	66.226	63.854	-0.218	-0.480	-5	-5
Percent Passing 4.75 mm	49.980	47.860	49.927	47.779	0.038	0.052	5	5
LS-603 Los Angeles Abrasion %	22.800	24.100	23.436	23.191	-0.588	0.646	-5	5
LS-607 Percent Crushed Particles	77.100	77.100	68.750	69.097	1.585	1.431	3	4
LS-608 % Flat & Elongated Particles	10.300	8.600	6.488	6.253	1.262	0.849	4	5
LS-609 Petrographic Number (Concrete)	104.60	110.90	114.39	112.95	-1.056	-0.281	Acceptable	
LS-614 Freeze - Thaw Loss, %	16.000	17.000	14.590	14.771	0.479	0.705	5	5
LS-618 Micro-Deval Abrasion Loss (CA)	12.000	12.200	11.492	11.435	0.829	1.057	5	4
LS-620 Accelerated Mortar Bar (14 Days)								

Blank spaces represent not tested.
* - Calculation considered outlier

Table 2. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 10, 2005

FINE AGGREGATE REFERENCE SAMPLES 1.05 & 2.05

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.05	2.05	1	2	1	2	1	2
LS-623								
Maximum Wet Density (g/cm^3)	2.311	2.317	2.308	2.306	0.083	0.274	5	5
Maximum Dry Density (g/cm^3)	2.140	2.145	2.134	2.133	0.132	0.244	5	5
Optimum Moisture, %	8.000	8.000	8.160	8.198	-0.339	-0.382	-5	-5
LS-604 – Coarse Aggregate								
Relative Density (O.D)	2.661	2.656	2.660	2.660	0.142	-0.485	5	-5
Absorption	1.500	1.600	1.544	1.549	-0.304	0.305	-5	5
LS-621								
Asphalt Coated Particles, %	42.600	41.500	39.427	40.088	0.878	0.453	5	5

Blank spaces represent not tested.
* - Calculation considered outlier

Table 3. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 10, 2005

FINE AGGREGATE REFERENCE SAMPLES 3.05 & 4.05

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.05	4.05	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D)	2.586	2.470	2.593	2.501	-0.387	-0.683	-5	-5
Absorption	1.810	3.210	1.713	3.109	0.321	0.129	5	5
LS-606 – Coarse Aggregate MgSO4 Soundness Loss, %								
LS-606 – Fine Aggregate MgSO4 Soundness Loss, %								
LS-619- Fine Aggregate								
Micro-Deval Abrasion	16.100	16.100	15.353	15.403	0.703	0.641	5	5
LS-611 Attrition Loss (FA), %								
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	38.900	33.600	37.446	36.164	0.841	-1.436	5	-4
Percent Passing 1.18 mm	26.900	22.500	25.692	25.011	0.792	-1.431	5	-4
Percent Passing 600 μm	17.700	14.800	17.021	16.585	0.600	-1.351	5	-4
Percent Passing 300 μm	12.600	10.700	11.959	11.630	0.755	-0.971	5	-5
Percent Passing 150 μm	10.000	9.000	9.428	9.181	0.837	-0.258	5	-5
Percent Passing 75 μm	8.370	7.310	7.836	7.626	0.884	-0.514	5	-5

Blank spaces represent not tested.
* - Calculation considered outlier

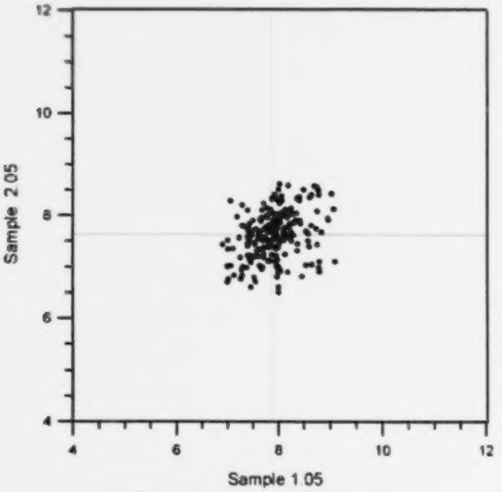
Table 4. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47 DATE PREPARED: November 10, 2005

SOILS REFERENCE SAMPLES 1.05 & 2.05

TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.05	2.05	1	2	1	2	1	2
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	100.00	100.00	99.961	99.966	-	-		
Percent Passing 425 μm	96.300	96.300	96.474	96.479	-0.495	-0.467	-5	-5
Percent Passing 75 μm	88.700	88.800	88.720	88.852	-0.035	-0.100	-5	-5
Percent Passing 20 μm	70.900	70.000	71.021	70.353	-0.025	-0.085	-5	-5
Percent Passing 5 μm	44.200	44.000	43.971	43.809	0.061	0.058	5	5
Percent Passing 2 μm	30.100	30.100	30.469	30.470	-0.118	-0.122	-5	-5
LS-703 Liquid Limit, %	28.500	28.800	27.721	27.656	0.546	0.778	5	5
LS-704								
Plastic Limit, %	16.500	16.600	15.578	15.537	0.706	0.686	5	5
Plasticity Index, %	12.000	12.200	12.331	12.294	-0.197	-0.051	-5	-5
LS-705 Specific Gravity of Soil	2.789	2.788	2.729	2.728	2.258	2.031	2	2
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	41.800	40.000	41.187	40.329	0.423	-0.237	5	-5
Sand Equivalent Value	32.300	32.300	30.738	30.028	0.418	0.806	5	5
Percent Fractured Particles	76.400	74.700	71.286	70.538	1.018	0.795	4	5
% Flat & Elongated Particles	2.700	2.600	1.142	1.179	2.257	2.116	2	2

Blank spaces represent not tested.
* - Calculation considered outlier

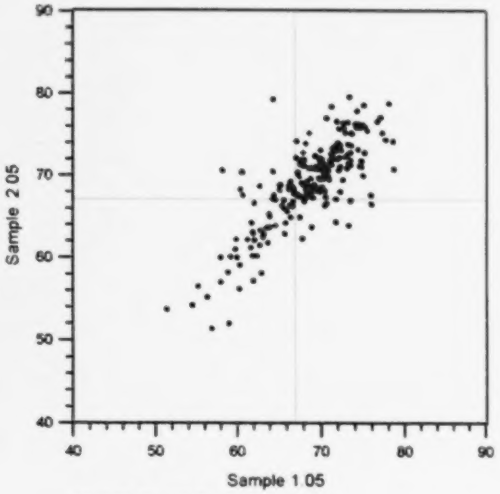


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.850	7.650
Median	7.800	7.500
Std Dev	0.604	0.614
n = 203		

Labs Eliminated: 447, 497, 452, 518

Scatter diagram for a test showing random variation with little laboratory bias

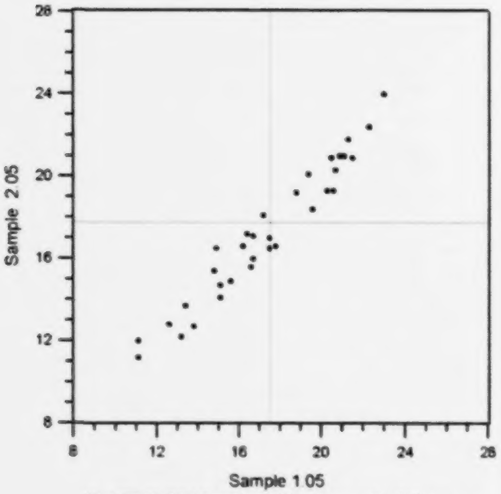


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	67.150	67.550
Median	68.300	64.500
Std Dev	4.920	4.860
n = 201		

Labs Eliminated: 345, 350, 436, 460

Scatter diagram for a test showing a combination of random variation and laboratory bias for some laboratories

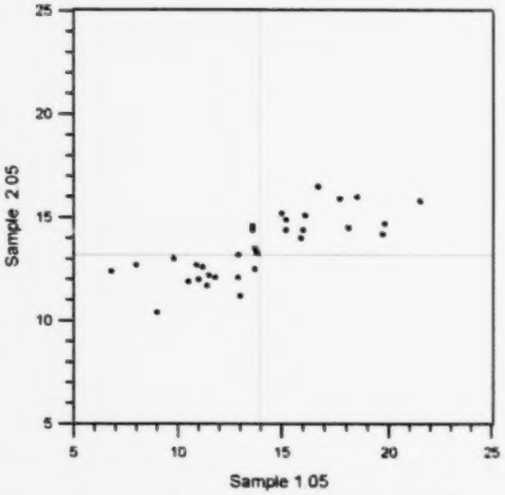


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.550	17.800
Median	15.800	15.600
Std Dev	3.266	3.475
n = 32		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.150	13.950
Median	12.900	13.600
Std Dev	3.375	2.985
n = 31		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1. Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected. The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution or universe.

The MTO study follows the criteria recommended for single samples in Section 4 of ASTM E 178 for rejecting the doubtful observations at the ninety-five percent confidence level. The critical value method is based on the assumption of normality and the critical values are calculated using Student's t distribution. The assumption in this method is that all the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting the outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation and standardised deviate.

In some cases, the strict application of the critical value method tends to include laboratories in the population who are not doing a good job. In those cases, the application of the iterative technique (Manchester[6]) is used. In the iterative technique, the Constant C is computed using Fisher's F distribution, and C depends on the number of participating laboratories. In this technique, an outlying observation is rejected based on a statistical criterion but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the iterative technique, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation (s) multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of critical value method.

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[6] The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

3. Discussion

The following discussion contains general and test-specific comments for the 2005 test period. Where ASTM or AASHTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Coarse and fine aggregate tests, including Sieve Analysis, Percent Crushed Particles, Relative Density and Absorption (FA), Moisture Density Relationship, Micro-Deval Abrasion Loss (FA), Magnesium Sulphate Soundness (FA), Uncompacted Void Content of Fine Aggregate, Sand Equivalent Value of Fine Aggregate, and Percent Fractured Particles - Granular 'A' from Franceschini Pit No. 2, Town of Caledon (MTO MAIDB No. O10-094).
- Coarse Aggregate tests, including Wash Pass 75 µm, Percent Flat and Elongated Particles, Relative Density and Absorption, Petrographic Analysis, Micro-Deval Abrasion Loss, and Percent Flat, Elongated, or Flat and Elongated Particles - HL8 Stone from Walker Brothers Vineland Quarry (MTO MAIDB No. N03-018).
- Magnesium Sulphate Soundness (CA) and Freeze - Thaw - HL8 Stone from Brechin Limestone Quarry (MTO MAIDB No. O11-047, Lafarge Canada Inc.).
- Fine Aggregate Petrographic Examination - Scalped sand from the Huron Construction pit (MTO MAIDB Number C08-003) 11.5 km east of Chatham.
- Soil tests - "Huron Slope" Physiographic Region located near Parkhill in West Williams Township.

3.2 NOTES ON SAMPLE PREPARATION

The material processed for the aggregate tests conforms approximately to a granular 'A' gradation. The aggregate samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). Twenty-five tonnes of granular 'A' were placed in layers into five separate stockpiles. A bobcat loader was used to fill an aggregate bin with small scoops from each stockpile in turn, in order to minimize sample bias. Material was fed along a conveyor belt to fill 30 identical bags (fitted with funnels) on a spinning turntable. It was found that 22 to 26 revolutions of the turntable were required to fill each bucket to approximately 30 Kg. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, five hundred 30 Kg samples were prepared and randomised for distribution to participating laboratories. The participants were responsible for the preparation of their own fine aggregate samples (3.05 and 4.05) from the two bags of granular 'A' delivered.

The soil was air-dried, processed passing 2.0 mm using a Fritsch Soil Mill Pulverizer, and placed in 20 Kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The hopper of the spinning riffle used is capable of filling 24 identical 2 Kg containers per run. This method was used to create uniform 20 Kg buckets. The correlation material was then prepared by obtaining representative samples from each 20 Kg bucket using the scoop method. The material collected from the 20 Kg buckets was then transferred to the hopper of the spinning riffle and the 500 g correlation samples were prepared. Then the samples were randomised for distribution to participating laboratories. The use of a spinning riffler ensured that as far as possible, each sample was identical to every other sample. It has been found that this is the best technique for minimising sample bias.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the scatter diagram. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in the Appendix C. Besides the comparison made to ASTM precision statements, comparison of the variation between test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasised that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 Wash Pass 75 µm (Coarse Aggregate) – Test No. 1

Two hundred and four laboratories participated in this test in 2005. Twelve outliers were identified and rejected using the critical value method. The standard deviation is consistent with the values obtained in 2002 and 2003, and is similar to the range of values published by

ASTM. However, the values are significantly higher than the standard deviation obtained in 2004. The scatter diagram shows a combination of random variation and laboratory bias for some laboratories. The laboratories that are identified as outliers or with a zero rating should examine their test procedure more closely and especially the achievement of constant dry mass at the beginning and end of the test.

3.4.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6

These tests represent the coarse aggregate portion of the sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.05 and 4.05), represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The samples were prepared with a large spinning riffler that is described in Section 3.2. This method of preparation minimises the sample variation and has resulted in negligible (1.0% to 2.4%) average gradation difference between samples 1.05 and 2.05. The variations found in 2005 for the coarse sieves, with the exception of 19.0 mm sieve, are consistent with that of the values obtained in 2002 and 2003. Further, the standard deviations are significantly lower than the values obtained in 2004 and the expected variations given in the ASTM precision statements.

Two hundred and six labs carried out the sieve analysis test. Outliers were eliminated using the critical value method. Successive scatter diagrams show a fairly uniform distribution of points about the mean. Three laboratories reported results that deviated considerably from the mean.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E-11 as guides) and your sieve shaker(s) thoroughly, and once satisfied that they are in order, perform a sieving efficiency test (MTO Method LS-602, Note 5) to pinpoint any problems.

3.4.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only eleven laboratories participated in this test. No outlier was detected by the use of critical value method or iterative technique. Considering the number of observations (11) used, the analysis may not yield a meaningful or representative statistical data. The lower left and upper right quadrants together account for eight of the eleven points, which is evidence of significant laboratory biases. This test shows systematic variation, as was found in previous years, but the variation in 2005 is similar to that of the values found in 2004.

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[7] Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10 to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, results from two different laboratories should not differ by more than 12.7%. The mean in this test (23.3%) is in the range of values for which ASTM data was established, and comparison indicates that this year's variation (average 4.5%) is same as that of the value given by ASTM.

3.4.4 Relative Density (Coarse Aggregate) - Test No. 9 and Absorption (Coarse Aggregate) – Test No. 10

Ninety-seven laboratories participated in these tests in 2005. Five laboratories in Test No. 9 and four laboratories in Test No. 10 were eliminated using the critical value method. The standard deviations obtained for bulk relative density (Test No. 9) are similar to that of the values found in the past three years, and considerably less than the values given in the ASTM precision statements. However, the variation for the absorption test (Test No. 10) is almost twice that of the values reported in the past studies and is similar to that of estimate provided in the ASTM precision statements. The latest version of ASTM C 127 does not provide precision estimate for absorption test. The expected variation shown on the precision table in Appendix C is based on the previous publication C 127 - 88. The high variation is probably due to the relatively high absorption of about 1.5% obtained with this coarse aggregate. The scatter diagrams for both of these tests show a combination of random variation and laboratory bias for some laboratories.

3.4.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11

Thirty-two laboratories performed this test in 2005, and one outlier was selected using the iterative technique. The scatter diagram shows a strong laboratory bias and all the points, with the exception of three, are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The coefficients of variations in 2005 (24.9%) are consistent with the values reported in 2002 and 2003, and noticeably lower than that of the value obtained in 2004 (34.9%). The coefficients of variation are similar to that of ASTM precision statements, which report a coefficient of variation of 25% for the percent loss range of 9 to 20.

3.4.6 Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

Two hundred and four laboratories performed the percent crushed particles test in 2005. Three outliers were selected by employing the critical value method. Variation (5.4%) is slightly lower than the value (6.0%)obtained during 1989 MTO workshop. The mean in this test (68.9%) is within the range of values (50% to 75%) for which the MTO precision statement was established. The variation in 2005 is also consistent with the values obtained from the 2002 and 2003 studies. The scatter diagram shows a random variation with noticeable laboratory operator bias. The samples distributed did not contain any cemented particles; therefore the percent cemented particles test was not evaluated this year. ASTM has a very similar test method (D 5821) but has not conducted inter-laboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2% for a mean value of 76.0%) obtained from MTO.

3.4.7 Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test.

One hundred and sixty eight laboratories reported test results for this test in 2005. The critical value method was used to reject six outliers. ASTM and CSA do not report precision for this test method. However, the studies conducted by MTO over the years indicate that the coefficient of variation decreases with the increase in the per cent flat and elongated particles. The average mean for this test reported since 2002 range from 3.3% to 9.0% and the corresponding coefficient of variations range from 64.8% to 39.8%. The average mean of 6.4% and the coefficient of variation of 43.7% in 2005 are consistent with the results reported in previous years. Eighty-nine percent of the points in the scatter diagram are accounted in the lower left and upper right quadrants indicating significant laboratory operator bias. In general, laboratories that reported values in excess of 12% or less than 3% should critically examine their equipment and procedure.

3.4.8 Petrographic Number (Concrete) – Test No. 14

The coarse aggregate examined in 2005 was asphalt-stone from Walker Brothers Vineland Quarry (MTO MAIDB No. N03-018).

Analysts from twenty-six laboratories examined samples 1.05 and 2.05 (full fraction), and submitted work sheets showing subdivision according to rock type and quality. Laboratories 13, 80, and 196 used the same analyst, as did 101 and 203.

In this test period the coarse aggregate was a quarried dolostone of the Lockport Formation. The material was a homogeneous slightly vuggy carbonate with fine to medium crystalline grain size, light brown colour. There were traces of gypsum in some particles which depending on quantity would be placed in the good category (less than 10% gypsum) or in the poor category (gypsum from 10-49%). Occasionally there were also pieces of gypsum (greater than 49% of the particle area) which would be classed as deleterious. There were also small amounts of chert (generally less than 2%). The dolostone was typically reported to contain mostly hard and medium hard carbonate with small amounts of soft or soft pitted carbonate. Different observers reported widely differing proportions of hard versus medium hard but both materials are considered good. There was virtually no shaley carbonate (poor), shale (deleterious) material or sandy carbonate.

This year we have treated as outliers any lab which failed to report most of the above materials in some quantity or if they reported excessive amounts of some material (chert for instance). Some observers did not recognize the presence of gypsum. This is an unusual material for many observers but not uncommon in the Niagara area. Those operators who did not recognize gypsum should review their samples to see if gypsum was overlooked.

Those operators which were rejected also reported the following materials to be present in the sample: sandstone (good and fair), siltstone (poor), shale, talc (probably gypsum). It was notable that observers in eastern Ontario often reported large amounts of sandy carbonate where other observers did not. The correct recognition of rock types is critical in petrographic examination and in cases of uncertainty requires microscopic examination sometimes combined with acid etching of the particle.

This is a procedure that is not necessarily appropriate for statistical analysis as is used with the other tests. This year it has been decided to not use a numerical rating system but to use the classification acceptable or unacceptable. The distribution of acceptable and unacceptable laboratories is shown in the scatter diagram. Those laboratories or operators who reported Petrographic Number results widely different from the mean should closely re-examine their sample in view of the discussion above.

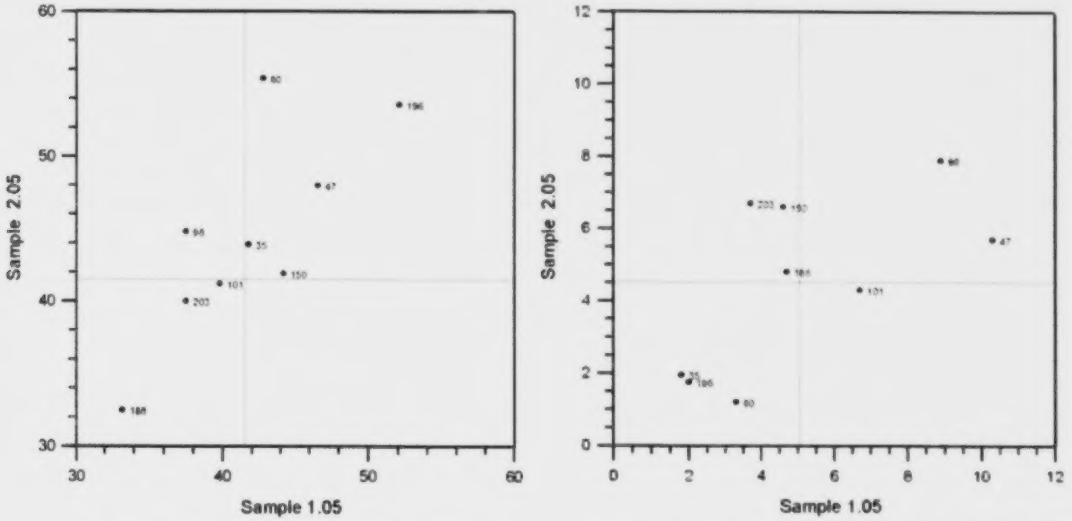
The similar ASTM standard for this test, C-295, does not report a petrographic number and has no precision statement.

3.4.9 Petrographic Analysis (Fine Aggregate)

The fine aggregate examined in 2004 was sand from the Huron Construction pit (MTO MAIDB Number C08-003) 11.5 km east of Chatham.

Analysts from nine laboratories examined samples 1.05 and 2.05, and submitted work sheets showing subdivision according to rock/mineral type and sieve size. Laboratories 80 and 196 used the same analyst, as did 101 and 203. The material this year was from the Chatham area and was a natural sand with large amounts of soft black coloured shale with a mixture of carbonate and silicate rocks. There were small amounts of chert (typically leached and lightweight).

All operators recognized the main components. There was some differences in measured proportions of rock types in the samples. Examples of these are shown in two scatter diagrams. One shows the shale content which is the average of the six sieve sizes examined. The other scatter diagram shows the chert content which is the average of the three largest sieve sizes examined. The three smaller sieves contained either no or negligible amounts of chert. Most operators did not observe any mica, or less than 1 % mica, on the 75 um sieve. Two operators did report either 3 or 4 % mica and the other 5 and 7 % mica.



(a) Shale Reported, Average of Six Sieve Sizes

(b) Chert Reported, Average of Three Largest Sieve Sizes

Figure 2. Fine Aggregate Petrographic Examination Scatter Digrams

Those who reported either relatively high or relatively low amounts of shale or chert or high amounts of mica should closely examine their samples to see if they correctly identified the materials.

The similar ASTM standard for this test, C-295, has no precision statement.

3.4.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Sixty-five laboratories reported results for this test in 2005. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, two laboratories reported control sample results outside the established range and the labs were excluded from the analysis. Two outliers were rejected using the iterative technique. The test method (LS-618) for coarse aggregate with a MDA value of 12 gives a multi-laboratory coefficient of variation of 6.4%. The mean in this test was 11.5, and the coefficient of variation of 5.8% obtained in 2005 is consistent with the value published in LS-618. The scatter plot for this test shows a combination of random variation and laboratory bias for some laboratories.

3.4.11 Freeze-Thaw Loss – Test No. 17

Fifty laboratories reported results for this test in 2005. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, section 9.1). This year, only one laboratory reported control sample data outside the established range, and it was excluded from the analysis. Two outliers were selected using the iterative technique. Variation is considerably higher than the multi-laboratory precision statements published in LS-614, but the coefficient of variation in 2005 (20.8%) is within the range of values (20.0% to 26.8%) reported in 2002 to 2004 studies. The scatter diagram shows evidence of a strong laboratory bias for this test. It is likely that there are two main reasons for the wide spread in data: insufficient damage caused by freezing which is due to freezing too rapidly or difference in sieving intensity. Laboratories should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. LS-614, Revision 22 (Appendix 1) in the MTO Laboratory Testing Manual gives a procedure for determining and adjusting sieving time for quantitative analysis. It is possible that increased use of this procedure to adjust sieving time might have a positive effect.

3.4.12 Sieve Analysis (Fine Aggregate) – Test No. 20-25

The samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve analysis show random variation with little laboratory bias. The standard deviations for the fine sieves (Test No. 20 to 25) in 2005 are slightly lower than that of the values reported in the studies of past three years, and are slightly higher than the values published in ASTM. As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained on the sieve, the more efficient the sieving process, and the better the precision. When there is a small amount of material on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

Altogether, four outlier laboratories were selected using the critical value method. Outlier labs with very low percent passing the 75 µm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing the sieve.

3.4.13 Relative Density (Fine Aggregate) – Test No. 27 and Absorption (Fine Aggregate) – Test No. 28

Ninety-five laboratories performed these tests in 2005. The ministry has been using the Test Method MTO LS-605 for the determination of bulk relative density and absorption of fine aggregates throughout its correlation studies. MTO LS-605 follows the ASTM C-128, except that it requires the removal of materials finer than 75 µm from the test specimen. The participants in the 2005 program were asked to test Sample 1.05 according to MTO LS-605 and Sample 2.05 in accordance with the procedures described in ASTM C 128. The significant difference between the methods is that Test Method LS-605 requires the test specimens to be prepared in duplicates and washed on the 75 µm sieve until all the material finer than 75 µm is removed. As a consequence, the tests results reported were obtained for the same materials with the only difference being the presence or absence of fines passing the 75 µm sieve and are reflected on the mean values of bulk relative density and absorption. In addition, the standard deviations obtained for Sample 2.05 is almost 2.5 times that of the Sample 1.05.

It can be seen that testing fine aggregate with the fines present results in a lower relative density by 0.09 and a higher absorption of 1.4%. This is almost certainly incorrect. Values obtained when the fines are removed, based on our knowledge of minerals and rocks present, are judged to be closer to reality. MTO is taking steps in 2006 to modify LS-605 so that for Superpave mix design purposes, LS-605 will be used. This will require washing of the fine aggregate prior to testing in contrast to the requirements of AASHTO T 84 and ASTM C 128.

Eight outliers for Test No. 27 and four outliers for Test No. 28 were selected using the iterative technique. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30 seconds periods of rest can be detrimental for the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values.

The standard deviation obtained for the relative density of Sample 1.05 is consistent with the 2004 results and is slightly higher than that of the values reported in prior years, but the multi-laboratory variation is noticeably less than the variation stated in ASTM C128. However, the standard deviation (0.045) obtained for Sample 2.05 is significantly higher the value (0.023) provided in the ASTM precision statements.

The ASTM precision statements, which report a standard deviation of 0.23 for materials with absorption, value less than 1%. The mean of Sample 1.05 and 2.05 are 1.7 and 3.1 times, respectively, that of the mean for which the precision statement was published. However, the coefficient of variation of Sample 1.05 (17.5%) and Sample 2.05 (25.1%) obtained in 2005 are comparable to that of ASTM value (23%). The scatter diagrams for both tests indicate a strong laboratory bias.

3.4.14 Magnesium Sulphate Soundness (Fine Aggregate) – Test No. 29

Thirty-one laboratories participated in this test in 2005. Two outliers were rejected using the iterative technique. All the data, with the exception of three, are accounted in the lower left (quadrant 3) and upper right (quadrant 1) with the axis of scatter of points at approximately 45 degrees. As in previous years, the scatter diagram shows strong laboratory bias. The average mean in this test was 17.1%, which is significantly higher than the mean loss reported in the past three years and a direct comparison of the standard deviation with the results from the previous studies may not be appropriate. However, the coefficient of variation 21.8% in 2005 is significantly lower than that of the variations (31.6% to 40.8%) obtained from 2002 to 2004 studies. The ASTM precision statements are for coarse aggregates only, and there is no established estimate for fine aggregates.

3.4.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30

Two hundred and two laboratories reported results in 2005. Fourteen laboratories were identified as outliers using the iterative technique. The scatter plot shows random variation with some laboratory bias. The variation in 2005 is noticeably lower than the values reported in the past three years. There is no comparable or similar ASTM test procedure, and no precision statement has been established by MTO. Laboratories, which reported values of less than about 33% and above 46%, should critically evaluate their interpretation of the definition and re-examine their samples.

3.4.16 Moisture-Density Relationship (One-Point Method) – Test Nos. 31-33

One hundred and forty-seven laboratories reported results for this test. Four outliers for Test No 31 and three outliers for Test No. 33 were rejected using the critical value method. The variations in 2005 are similar to that of the values reported in the previous three years. The majority of the points in the scatter diagrams are located in the lower left and upper right quadrant of the plots with strong laboratory bias showing testing rather than the material variability is the source of the errors. The possible causes for the bias may be operator error and the use of an improper mould even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no ASTM precision statement for this test.

3.4.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants were asked to prepare their own test sample from the bulk sample provided. Sixty-five laboratories participated in this test in 2005. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. This year, all the laboratories reported control sample result within the range established for the material. Eighty three percent of the data points are located in the lower left and upper right quadrant of the scatter diagram indicating a strong laboratory bias. Three outliers were selected using the iterative technique. The standard deviation (1.1) and the coefficient of variation (7.2%) in 2005 are slightly higher than the multi-laboratory coefficient of variation (5.6%) published in the test method (LS-619). But the values are noticeably lower than the standard deviation(1.5) and coefficient of variation (8.7%) obtained in 2004.

3.4.18 Particle Analysis of Soil – Test Nos. 40-45

Sixty-seven laboratories reported results for the hydrometer test in 2005. Test 40 is reported for information purposes only, because 88% of the participants reported 100% passing 2.00 mm. Outliers were selected using the iterative technique. Participants were requested to perform the test according to MTO LS-702, Revision No.19 and to verify this, they were asked to submit the data sheet. The data sheets submitted by the participants indicate that all the laboratories did perform the test in accordance with test procedure.

The scatter diagrams show significant laboratory biases, especially in the case of percent passing 5μm and 2μm. The standard deviations for each of these particle sizes are consistent with the values reported in the 2002 to 2004 studies.

The laboratories that are identified as outliers should examine their equipment and procedure very carefully to make certain all is within specification and the procedure is followed exactly.

3.4.19 Atterberg Limits of Soil – Test Nos. 46-48

Seventy-seven laboratories reported results for Atterberg Limit tests in 2005. Altogether four outlier laboratories were identified using the critical value method. The scatter plots for both Liquid and Plastic Limits show strong laboratory bias. This variation is characteristic of tests that require significant operator skills, and good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The variations obtained for all three tests in 2004, i.e., liquid, plastic limits, and plasticity index are fairly consistent with the values reported in 2002 to 2004 studies. The standard deviations for the liquid limit test are slightly higher than the values published in ASTM, but the standard deviations obtained for plastic limit and plasticity index are consistent with those of ASTM.

3.4.20 Specific Gravity of Soils – Test No. 49

Fifty-eight laboratories reported results for this test. The participants were requested to perform the test on a minimum of three specimens in accordance with the procedures described in Section 7.1of MTO LS-705, Revision No. 20. They were asked to submit the data sheet to verify if the range, i.e., the difference between the largest and smallest value, is within the limit specified (0.02) in the test method. Based on the data sheet, two laboratories exceeded the limit and were excluded from the analysis. Four outliers were also detected using the iterative technique. Ninety percent of the plots are located in 1st and 3rd quadrants of the scatter diagram showing a strong laboratory bias. Several steps in this test procedure can influence the results. Particularly, the equipment and method employed for preparation of test specimen as well as for removal of air entrapped in the pycnometer or flask. The possible cause for the bias may be because the laboratories do not fully comply with the test procedures. Laboratories finding themselves in this situation should examine their equipment and procedure very carefully.

The test method MTO LS-705 is similar to that of AASHTO T 100, which reports a standard deviation of 0.04. The standard deviations obtained in 2005 are similar to the values that were obtained in 2004 and are considerably lower than the value published in AASHTO T 100.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 Uncompacted Void Content (FA) – Test No. 95

The participants were asked to prepare the fine aggregate by splitting the material passing 4.75 mm sieve and perform the test in accordance with Test Method A of ASTM C 1252, i.e., standard graded sample. Fifty-one laboratories submitted results for this test. One laboratory was identified as an outlier using the critical value method. The scatter diagram shows a combination of random variation and laboratory bias for some laboratories.

The standard deviations in 2005 are consistent with the values that were reported in 2003 and 2004, and are considerably higher than the values published in ASTM for graded standard sand (0.33%). The estimates of precision in ASTM are based on graded sand as described in ASTM C 778, which is considered rounded and is graded from 600 µm to 150 µm, and may not be typical of the samples that were supplied for this testing program. The finer portion (passing 4.75 mm sieve) of the aggregate samples that we have been using for the proficiency program are similar to that of manufactured fine aggregate for which ASTM reports a standard deviation of 1.1%. The standard deviations obtained in 2005 (1.45% and 1.39%) are closer to the values published for manufactured fine aggregate, i.e., Test Method C - As Received Grading. The bulk dry relative density values used by the participants for the computation of void content range from 2.430 to 2.662, and differ by 0.232. The ASTM C 1252 suggests that a difference in relative density of 0.05 will change the calculated void content by about one percent. The number of participants in this test has increased from 20 in 2002 to 51 in 2005. Poor performance in this test by many labs is probably due to lack of familiarity with this test procedure that was recently introduced by most of the participants in their laboratories. The wide variation in bulk density used in the calculation is also a significant source of error. It is hoped that improvements to LS-605 will also result in improvement in variation of this test.

3.5.2 Sand Equivalent Value of Fine Aggregate – Test No. 96

The participants were asked to prepare the fine aggregate sample for this test by splitting the material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO Methods. The participants were given the option of preparing the test specimen in accordance with either method.

Forty-nine laboratories participated in this test in 2005 compared to eighteen in 2002. Seven outliers were identified by the iterative technique. The lower left and upper right quadrants of the scatter diagram together account for 84% of the points showing significant laboratory bias. The standard deviations obtained in 2005 (3.7 and 2.8) are significantly lower than values reported in 2004 (8.6) and the multi-laboratory precision value (8.0) published by ASTM for samples with sand equivalent value less than 80. Further, the variations in 2005 are consistent with the values reported in 2002 and 2003, and notably, the mean sand equivalent values of 2003 and 2005 are almost identical.

3.5.3 Percent of Fractured Particles in Coarse Aggregate – Test No. 97

The samples supplied did not contain adequate material retained on 19.0 mm sieve. Because of this, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only.

Fifty-three laboratories submitted results for this test in 2005. The number of participants in this test has risen by 33 since 2002. No outlier was detected using the critical value method or iterative technique. The scatter diagram shows a strong laboratory bias. The average mean values of the ASTM and MTO versions of the test on the same aggregate are 70.9% and 68.9%, respectively but the standard deviations obtained by both test methods, ASTM (5.1%) and MTO (5.4%), differ by a very narrow margin. The ASTM test method is very similar to MTO LS-607, but ASTM has not conducted inter-laboratory studies to determine precision and currently publishes statistical data obtained by MTO. The variation in 2005 study (5.4%) is comparable to the value (5.2%) published in ASTM precision statements.

3.5.4 Percent Flat and Elongated Particles in Coarse Aggregate – Test No. 99

The samples supplied did not contain adequate material retained on 19.0 mm sieve. Because of this, the participants were advised to perform the test on coarse aggregate passing the 19.0 mm sieve only using a ratio of 5:1.

Fifty-three laboratories performed this test in 2005. Seven outliers were detected using the iterative technique. The standard deviations obtained in 2005 are noticeably lower than that of 2004 and consistent with the values that were reported in 2002 and 2003. There is no ASTM precision statement for this test.

4. Laboratory Rating System

The laboratory rating system assigns separate ratings for low complexity (production) aggregate laboratories, high complexity (full service) aggregate laboratories, and for soil laboratories. Low complexity laboratories are required to carry out wash pass 75 µm, gradation, percent crushed particles, percent asphalt coated particles, and optional, percent flat and elongated particles. In addition to those low complexity tests, high complexity laboratories must carry out micro-Deval (coarse and fine), freeze-thaw and/or magnesium sulphate soundness, relative density and absorption (coarse & fine). Forty-seven (47) high complexity (full service) aggregate laboratories participated in the program in 2005. Soil laboratories are required to carry out particle size analysis, Atterberg limits and specific gravity of soil. Fifty-six (56) laboratories participated in all three soil tests, in 2005.

A similar laboratory rating system is also used for assigning laboratory ratings for Superpave aggregate laboratories. The laboratories are required to perform all four tests, i.e., uncompacted void content of fine aggregate, sand equivalent value of fine aggregate, percent fractured particles in coarse aggregate, and flat and elongated particles in coarse aggregate. Forty-nine of the fifty-three laboratories have submitted results for all four tests.

The rating system gives a maximum of 10 for each test, *e.g.* 5 for wash pass 75 µm on sample 1.05, plus -5 for wash pass 75 µm on sample 2.05, equals 10 (the negative sign indicating a test result less than the mean is ignored). Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the gradation results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by the number of sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Aggregate, soil, and Superpave laboratory ratings are given in Figures 3 and 4. The laboratory rating system data is reported in the Appendices E1, E2, E3, and E4.

Laboratory ratings are given in the covering letter accompanying this report to individual laboratories. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.

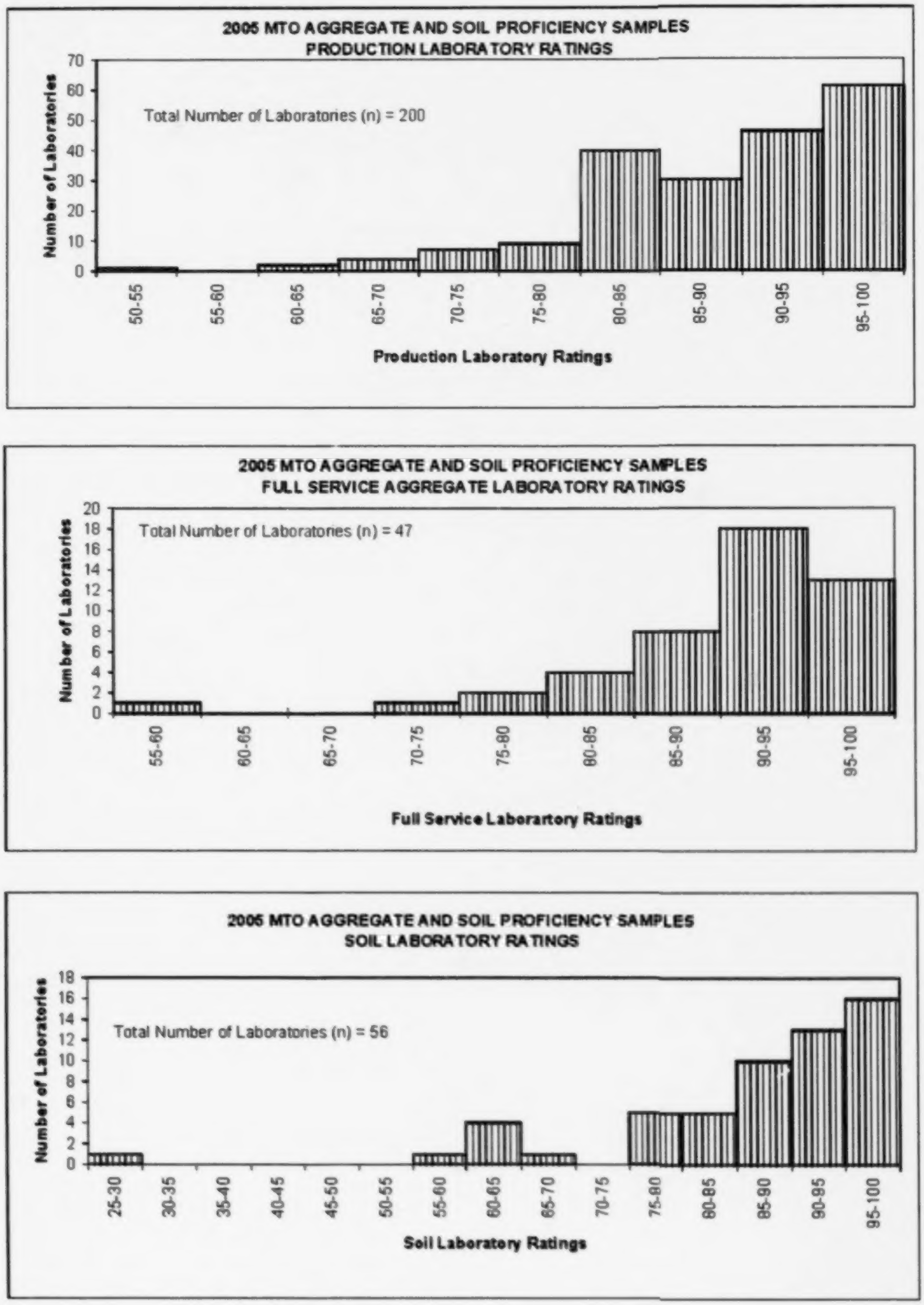


Figure 3. Laboratory Ratings

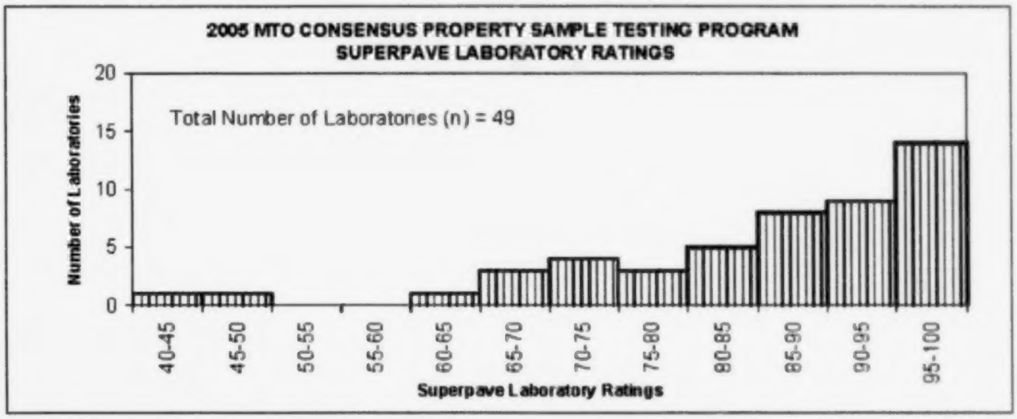


Figure 4. Superpave Laboratory Ratings

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in no significant (coarse and fine aggregate) mean gradation differences between samples 1.05 and 2.05. In fact, the multi-laboratory variations for gradation test results since 1999 are similar or significantly lower than the variations given in the ASTM precision statements. The differences in mean as well as in variations between pairs of samples for both, coarse and fine sieves, are negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform material at reasonable cost.

The majority of the aggregate and soil test results of the 2005 Proficiency Sample Testing Program compare favourably but also in some cases show noticeable improvement over previous year's results. The variations in most of the tests are more or less similar to the values reported in the last four years. The scatter diagrams for majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

One hundred and ninety-four of the laboratories participated in the aggregate tests are CCIL Type C (low complexity tests) certified and forty-seven of those are certified for high complexity tests (Type D). CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about eighteen months intervals. The aggregate tests are probably showing general improvement, in large part, due to the CCIL laboratory inspection and certification program, and due to an increased awareness of the importance of proper testing.

The variations found in 2005 for all the soil tests are consistent with the values reported in the last three years' studies, but the scatter diagrams still show strong laboratory biases. The results of soil tests are significantly influenced by the operator skills, testing environment, and the condition and calibration of the equipment. Twenty- four of the fifty-six laboratories participated in the soil tests do not participate in the MTO on-site lab inspection program[8], which is voluntary. Most of the laboratories that are in the MTO Vendors list were inspected about four years ago and little re-inspection has been done to date.

The results of 2005 Superpave consensus property tests are not only consistent with the results of previous years, but show improvements in the case of sand equivalent value, and flat and elongated particles of coarse aggregate. Further, the multi-laboratory precisions obtained, with the exception of uncompacted void content, are comparable to the values published in ASTM precision statements. However, the scatter diagrams show strong laboratory biases. Most of the laboratories participated in this program have limited experience in these test procedures. The laboratory inspection program introduced by CCIL in 2003 should bring about improvements in variation and reduce laboratory biases.

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[8] To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235 – 4901, fax (416) 235 – 4101.

6. Recommendations

Although, there are some noticeable reductions in multi-laboratory variation, strong laboratory biases still remain in number of test procedures. The laboratories that were identified as outliers and or obtained zero ratings should examine the condition and calibration of equipment, testing procedures, and skills of the technicians. It is good practice to do this whenever a rating of 2 or less is obtained.

The results of the 2005 MTO Aggregate and Soil Proficiency Sample Program suggest that most laboratories have satisfactory within-laboratory precision, but the multi-laboratory precision needs to be improved for a number of tests. The laboratories must focus on operator training, standardization and calibration of equipment, and laboratory environment in order to improve the multi-laboratory precision.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of maintenance, repair and correct calibration are sometimes lacking. It is hoped that the mandatory Quality System implemented by CCIL in the spring of 2002 will encourage laboratories to conduct self-examination to ensure they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples, are beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

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References

1. American Society for Testing and Materials 2002. Annual Book of ASTM Standards, Vol. 04.02, Concrete and Aggregate
2. American Society for Testing and Materials 2002. Annual Book of ASTM Standards, Vol. 14.02, Statistical Methods
3. Grubbs, F. E. and Beck, G., " Extension of Sample Sizes and Percentage Points for Significance Tests of Outlying Observations", Technometrics, TCMTA, Vol. 14, No. 4, November 1972, pp. 847 – 854.
4. Grubbs, F. E., " Procedures for Detecting Outlying Observations in Samples", Technometrics, TCMTA, Vol. 11, No. 4, February 1969, pp. 1 – 21.
5. Manchester, L., 1979, "The Development of an Interlaboratory Testing Program for Construction Aggregates", Engineering Materials Office Report 6 EM-33, Ministry of Transportation, Ontario
6. Vasavithasan, M. and Rutter, B., 2004, "User's Manual for Soils and Aggregates Sample Testing (SASTP) Computer Program ", Materials Engineering and Research Report MERO-013, Ministry of Transportation, Ontario
7. Vogler, R. H. and Spellenberg, P. A., "AASHTO T 27 – Sieve Analysis of Fine and Coarse Aggregate", Technical Section 1c, Unpublished Paper

Appendix A: Glossary of Terms

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value.' This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process, and an accepted reference value of the property being measured. For the majority of aggregate and soil tests there is no acceptable reference material, so bias is impossible to compute.

Critical Value is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$\text{C.V.} = \frac{\text{std dev}}{\text{mean}} \text{ x } 100$$

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Multi-laboratory precision (one-sigma limit (1s)) is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances the estimates of the one-sigma limit for multi-laboratory precision are usually larger than those for single operator precision because different operators and different equipment are being used in different laboratories.

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s), by the factor $2\sqrt{2}$ (2.83).

Sample mean or average is the sum of all observations divided by the total number of observations.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the

sample median is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier it means something went wrong either with the sample or in the laboratory.

Appendix B1: List of Participants

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Limited Moose Creek, ON Mr. B. Blanshard Tel: 613 538-2271	✓	✓				✓								✓				
Acculab Engineering and Testing Schumacher, ON Mr. H.R. Jones Tel: 705 360-5252	✓	✓				✓	✓							✓	✓			
AGS Associates Inc. Scarborough, ON Mr. A. Chohan Tel: 416 299-3655	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
AME - Materials Engineering – East Gormley, ON Mr. B. Dobson Tel: 905 640-7772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
AME - Materials Engineering (24-165) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-270) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-271) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-272) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME - Materials Engineering (24-298) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-911) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME - Materials Engineering (24-912) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓								✓	✓			
AME -Materials Engineering Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
AME -Materials Engineering - Ottawa Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓							✓	✓			
AME -Materials Engineering (24-297) Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓				✓	✓				✓	✓		✓	✓			

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AMEC Earth & Environmental Ltd Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. J. Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Orillia, ON Mr. Don Nicol Tel: 705 329-1542	✓	✓				✓								✓	✓			
AMEC Earth & Environmental Ltd. Thorold, ON Mr. A. Markov Tel: 905 687-6616	✓	✓				✓								✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Waterloo, ON Mr. L. Maier Tel: 519 885-6220	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Bernt Gilbertson Enterprises Richards Landing, ON, Mr. S. Eddy Tel: 705 246-2076	✓	✓				✓								✓				
Bertrand Construction L'Original, ON Mr. P. Arnold Tel: 613 675-4614	✓	✓				✓	✓				✓	✓		✓				
Block & Associates Winnipeg, Manitoba Mr. Gordon Richards Tel: 204 334-5356		✓	✓	✓	✓		✓							✓	✓	✓	✓	✓
BOT Construction Oakville, ON Mr. Vicks Sellathurai Tel: 905 827-3250	✓	✓				✓								✓	✓			
Bruno's Contracting (Thunder Bay) Ltd. No. 376, Thunder Bay, ON Mr. B. Prevost Tel: 807 623-1855	✓	✓		✓		✓	✓							✓				
C. Villeneuve Construction Hearst, ON Mr. C. Harris Tel: 705 372-1838	✓	✓		✓		✓	✓							✓	✓			
C.T. Soil & Materials Engineering Inc. Windsor, ON Mr. T. J. O'Dwyer Tel: 519 966-8863	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Caledon Sand & Gravel Ltd. Caledon, ON Mr. D. Glenn Tel: 519 927-5224	✓	✓				✓								✓				
Capital Paving Inc. (Asphalt Laboratory) Guelph, ON Mr. M. Latyn Tel: 519 822-4511	✓	✓				✓								✓	✓			
CBM Aggregates Cambridge, ON Mr. L. Mugford Tel: 519 740-3053	✓	✓				✓								✓				
CBM Aggregates – Brighton Lab Brighton, ON Mr. L. Mugford Tel: 613 475-2420	✓	✓				✓								✓				
CBM Aggregates Aberfoyle Lab Cambridge, ON Mr. L. Mugford Tel: 519 824-8169	✓	✓				✓	✓							✓				

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
CBM Leaside Lab Toronto, ON Mr. S. Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
CBM Sunderland Lab Sunderland, ON Mr. L. Mugford Tel: 416 862-1382	✓	✓				✓	✓							✓				
Chung & Vander Dollen Engineering Limited, Kitchener, ON Mr. W. Evans Tel: 519 742-8979	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
City of Sault Ste Marie Sault Ste Marie, ON Mr. J. Sloan Tel: 705 946-9918	✓	✓				✓								✓				
COCO Paving Inc. Windsor, ON Mr. Ernie Scerbo Tel: 519 948-7133	✓	✓				✓	✓							✓	✓			
Concrete Materials Lab, Dept of Engineering, U. Of Toronto Dr. R. D. Hooton Tel: 416 978-5912													✓					
Consoil Quality Control St. Catharines, ON Mr. J. Clunas Tel: 905 641-1162	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Construction Control Inc. Woodbridge, ON Mr. A. Davis Tel: 905 856-1438	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. P. Lung Tel: 905 469-6352	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Cornwall Gravel Company Limited. Cornwall, ON Mr. B. Mroz Tel: 613 932-6571	✓	✓				✓								✓				
Cox Construction Limited Guelph, ON Mr. Arlaan Warren Tel: 519 824-6570	✓	✓				✓	✓							✓				
Cruickshank Construction Ltd Kingston, ON Mr. Tim Bilton Tel: 613 542-2874	✓	✓				✓								✓				
Cruickshank Construction Ltd Morrisburg, ON Mr. D. Byvelds Tel: 613 543-2978	✓	✓				✓	✓							✓	✓			
D.F. Elliott Consulting Engineering New Liskeard, ON Mr. B. Gilbert Tel: 705 647-6871	✓	✓				✓	✓							✓	✓			
Davroc Testing Laboratories Inc. Brampton, ON Mr. S. Fasullo Tel: 905 792-7792	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Mobile 10 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
DBA Engineering Limited Mobile 5 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Limited Mobile 6 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Limited Mobile 7 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓	✓			
DBA Engineering Ltd. Kingston, ON Mr. M. McClelland Tel: 613 389-1781	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
District Municipality of Muskoka Bracebridge, ON Mr. D. Wood Tel: 705 645-6764	✓	✓				✓	✓							✓	✓	✓	✓	
Drain Bros Excavating Ltd. Lakefield, ON Mr. D. Drain Tel: 705 639-2301	✓	✓				✓	✓				✓	✓		✓	✓			
DST Consulting Engineers Inc. Kenora, ON Mr. W. Foster Tel: 807 548-2383	✓	✓				✓	✓							✓	✓	✓	✓	
DST Consulting Engineers Inc. Thunder Bay, ON Mr. Scott Tozer Tel: 807 623-2929	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
DST Consulting Engineers Inc. Ottawa, ON Mr. J. Lajeunesse Tel: 613 748-1415	✓	✓				✓								✓	✓	✓	✓	
Dufferin Aggregates - Aberfoyle Lab Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Acton Lab Milton, ON Mr.Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates – Blair Pit Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Carden Lab Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Cayuga Cayuga, ON Mr. Maurice Guimont Tel: 905 772-3331	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Dufferin Aggregates – Flamborough Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates – London Lab London, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Aggregates - Millcreek Lab Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				

2005 Participants List

Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Dufferin Aggregates – Milton Lab Milton, ON Mr. Maurice Guimont Tel: 416 798-4772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	
Dufferin Aggregates - Mosport Lab Milton, ON Mr. Maurice Guimont Tel: 905 878-2732	✓	✓				✓	✓							✓				
Dufferin Construction Ltd. (QC) – Bronte Lab, Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Dufferin Construction Ltd. Mobile Lab 1 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓			
Dufferin Construction Ltd. Mobile Lab 2 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
E.C. King Contracting Lab #1 Owen Sound, ON Mr. H. Villneff Sr. Tel: 705 472-3312	✓	✓				✓	✓							✓				
Esko Savela & Son Contracting Inc. Thunder Bay, ON, Mr. E. Savela Tel: 807 983-2097	✓	✓				✓								✓				
Fermar Construction Limited Rexdale, ON, Mr.Di Francescantonio Tel: 416 675-3550	✓	✓		✓		✓	✓							✓	✓			
Fowler Construction Company Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Fowler Construction Company Mobile1 Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓		✓		✓	✓				✓	✓		✓	✓			
G. Tackaberry & Sons Construction Co. Ltd., Athens, ON Mr. P. Rodgers Tel: 613 924-2634	✓	✓				✓	✓							✓	✓			
Gamsby and Mannerow Limited Owen Sound, ON Mr. B. Dubeau Tel: 519 376-1805	✓	✓				✓	✓							✓	✓			
Gazzola Paving Ltd. Etobicoke, ON Mr. S. Andualem Tel: 416 675-7007	✓	✓		✓		✓	✓							✓				
Geo Terre Limited Brampton, ON Ms. B. Vujanovic Tel: 905 455-5666	✓	✓				✓								✓	✓	✓	✓	
Geo-Logic Inc. Peterborough, ON Mr. W. Rayfuse Tel: 705 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Geo-Logic Inc. Pembroke, ON Ms. E. Reid Tel: 613 735-8361	✓	✓				✓								✓	✓			
Georgian Aggregates & Construction Collingwood, ON Mr. Tom Risi Tel: 705 445-2300	✓	✓		✓		✓	✓			✓	✓	✓		✓				

2005 Participants List Ministry of Transportation Aggregate and Soil *Proficiency Sample* Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Golder Associates Ltd. London, ON Mr. C. Sewell Tel: 519 652-0099	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Mississauga, ON Ms. M. Manojlovic Tel: 905 567-4444	✓	✓				✓								✓	✓	✓	✓	✓
Golder Associates Ltd. Ottawa, ON Ms. B. Jackson Tel: 613 224-5864	✓	✓		✓	✓	✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. J. Watkins Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Golder Associates Ltd. Windsor, ON Mr. R. Walsh Tel: 519 250-3733	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Graham Brothers Construction Limited Brampton, ON Mr. G. Thompson Tel: 905 453-1200	✓	✓		✓		✓	✓				✓	✓		✓	✓		✓	
Hard Rock Paving Company Limited Port Colborne, ON Ms. J. Koros Tel: 905 834-4581	✓	✓				✓	✓				✓	✓		✓	✓			
Harold Sutherland Construction Ltd. Kemble, ON Mr. R. Leigh Tel: 519 376-0603	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Holger Lohse, Consulting Gelogist Adjala, ON Mr. Holger Lohse Tel: 519 941-0875								✓	✓									
Huron Construction Lab No. 1 Chatham, ON Mr. D. Smith Tel: 519 354-0170	✓	✓				✓	✓							✓	✓			
Inspec-sol Inc. - Kingston Kingston, ON Mr. Joseph Bennett Tel: 613 389-9812	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Inspec-Sol Inc. - Mississauga Mississauga, ON Mr. K. Roechner Tel: 905 712-4771	✓	✓				✓								✓	✓	✓	✓	
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. F. Miles Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
J & P Leveque Bros. Ltd. Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
J & P Leveque Bros. Ltd. Mobile 1 Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓	✓		✓	
Jacques Whitford Limited Ottawa, ON Mr. B. Prevost Tel: 613 738-0708	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Jacques Whitford Limited Markham. ON Mr. I. Patel Tel: 416 495-8614	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
John D. Paterson & Associates Nepean, ON Mr. C. Pelletier Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
John Emery Geotechnical Engineering Ltd, Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
John Emery Geotechnical Engineering Mobile 4, Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓				✓	✓							✓	✓			
John Emery Geotechnical Engineering Mobile 6, Toronto, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓				✓	✓							✓	✓			
K.J. Beamish Construction King City, ON Mr. C. Henderson Tel: 905 833-4666	✓	✓		✓		✓	✓	✓			✓	✓		✓	✓		✓	
K.J. Beamish Construction Mobile 1 King City, ON Mr. C. Henderson Tel: 905 833-4666	✓	✓				✓	✓							✓	✓			
Karson Kartage & Konstruction Stittsville, ON Mr. C. MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Lafarge Canada Montreal, QUE, Ms. M. de Grosbois Tel: 514 738-1202													✓					
Lafarge Canada - Kitchener Kitchener, ON Mr. A. Smith Tel: 519 696-2274	✓	✓		✓		✓	✓							✓				
Lafarge Canada – Mosport Lab Orono, ON Mr. P. Hill Tel: 905 983-9260	✓	✓				✓	✓											
Lafarge Canada – Orillia Lab Brechin, ON Mr. Jeff Chebottn Tel: 705 686-7262	✓	✓				✓	✓							✓				
Lafarge Canada Brechin Plant Brechin, ON Mr. Shayne Davis Tel: 705 484-5225	✓	✓		✓		✓	✓				✓	✓		✓				
Lafarge Canada Coldwater Plant Cold Water, ON Ms. W. Todd Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Stouffville, ON Mr. M. Hicks Tel: 905 640-7092	✓	✓		✓		✓	✓							✓	✓			
Lafarge Canada Inc. – Byron Lab London, ON Mr. Walter Day Tel: 519 471-0520	✓	✓				✓								✓				

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Lafarge Canada Inc. – Fonthill Lab Fonthill, ON Mr. J. Vingerhoets Tel: 905 892-2686	✓	✓				✓	✓							✓				
Lafarge Canada Inc. – Hamilton Lab Hamilton, ON Mr. Chris Thomas Tel: 905 522-7735	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓			✓	
Lafarge Canada Inc. – Meldrum Lab Meldrum Bay, ON Mr. Jeff Middleton Tel: 705 283-3011	✓	✓				✓	✓							✓				
Lafarge Canada Inc. – Ottawa Ottawa, ON Mr. F. Douglas Tel: 613 837-4223	✓	✓				✓	✓				✓	✓		✓				
Lafarge Canada Inc. – Research lab Mississauga, ON Mr. Paul Lum Tel: 905 819-1290	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓			
Lafarge Canada Limited – Caledon Lab Caledon, ON Mr. J. Kroeze Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Construction Materials Ltd. – Brockville Lab, Brockville, ON Mr. P. Arkeveld Tel: 613 342-0262	✓	✓				✓	✓			✓				✓				
Lafarge Construction Materials Ltd. – Glenburnie Lab, Brockville, ON Mr. P. Arkeveld Tel: 613 342-0262	✓	✓				✓	✓							✓				
Lafarge Paving & Construction Toronto, ON Mr. A. Pahalan Tel: 416 633-9670	✓	✓		✓		✓	✓							✓				
Lafarge Paving & Construction (Eastern) Ltd. - Moodie Lab, Nepean, ON Mr. B. Gooderham Tel: 613 829-1770	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Lafarge Paving & Construction (Eastern) Ltd., Bellville, ON Mr. Gary Bates Tel: 613 962-2461		✓				✓	✓							✓				
Lafarge Paving & Construction Limited London, ON Mr. Shawn Dietze Tel: 519 451-2750		✓				✓	✓							✓				
Lafarge Quarries – Dundas Lab Dundas, ON Mr. Ryan Smith Tel: 905 527-3671	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Landtek Limited Hamilton, ON Mr. P. Anderson Tel: 905 383-3733	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, ON Mr. A. Gardner Tel: 519 482-3694	✓	✓				✓	✓							✓				
Law Engineering (London) Inc. London, ON Mr. J. Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Leo Alarie and Sons Limited Timmins, ON Mr. J. Luthe Tel: 705 268-2106	✓	✓				✓	✓							✓				

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
M.J. Labelle Co. Ltd. Mobile 1 Cochrane, ON Mr. P. Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M.J. Labelle Co. Ltd. Mobile 2 Cochrane, ON Mr. P. Osmar Tel: 705 272-4201	✓	✓				✓								✓	✓			
M.R. Wright & Associates Sault Ste. Marie, ON Mr. R. Wilson Tel: 705 945-5091	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓		
Mark Smereczynsky Petrographic Services, Etobicoke, ON Mr.M.Smereczynsky Tel: 416 626-3505								✓	✓									
McAsphalt Engineering Services Toronto, ON Mr. K. Davidson Tel: 416 281-8181	✓	✓		✓		✓	✓							✓	✓			
Merlex Engineering Ltd. North Bay, ON Mr. J. P. Duhaime Tel: 705 476-2550	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Mill-Am Corporation Lab #890901 Oldcastle, ON Mr. H. Villneff Sr. Tel: 519 945-7441	✓	✓				✓	✓							✓	✓			
Miller Northwest – 87526 Dryden, ON Mr. H. Villneff Sr. Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Northwest – Mobile 1 Dryden, ON Mr. H. Villneff Sr. Tel: 807 223-2844	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. - Carden Quarry Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓				✓	✓							✓				
Miller Paving Ltd. - Markham Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
Miller Paving Ltd. - Whitby Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Ltd. North Bay - #8661 North Bay, ON Mr. H. Villneff Sr. Tel: 705 472-3312	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - 1084 North Bay, ON Mr. H. Villneff Tel: 705 267-1107	✓	✓		✓		✓	✓							✓	✓			
Miller Paving Northern - 1254 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓		✓		✓	✓				✓	✓		✓	✓			
Miller Paving Northern - 60889 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓				✓	✓							✓	✓			
Miller Paving Northern - Mobile #60900 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓				✓	✓							✓	✓			

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Ministry of Transportation Downsview, ON Mr. C. Rogers Tel: 416 235-3734	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MNA Associates Limited Scarborough, ON Mr. P. Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Mulder Construction & Materials Limited, Unit # 7005, West St. Paul, MB Mr. D. Walker Tel: 204 958-7400	✓	✓				✓												
National Testing Laboratories Ltd. Winnipeg, Manitoba Mr. D. Flatt Tel: 204 488-6999	✓	✓	✓	✓											✓			
Naylor Engineering Associates Ltd Kitchener, ON Ms. Anne Allen Tel: 519 741-1313	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Nelson Aggregate Co. Beamsville, ON Mr. T. Scambato Tel: 905 563-8226	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Burlington, ON Mr. Steve Drew Tel: 905 335-5251	✓	✓				✓	✓							✓				
Peto MacCallum Ltd. Barrie, ON Mr. T. Lee-Bun Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Ltd. Brampton, ON Mr. R. Midgley Tel: 905 796-3650		✓		✓		✓	✓							✓	✓			
Peto MacCallum Ltd. Hamilton, ON Mr. E.L. Truax Tel: 905 561-2231	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Ltd. Kitchener, ON Mr. T. Smith Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Ltd. Toronto, ON Mr. A. Nathoo Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Pioneer Construction Inc. – East Main Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓			
Pioneer Construction Inc. – Kenora C-1 Kenora, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓								✓	✓			
Pioneer Construction Inc. - Mobile 1 Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile 2 Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. - Mobile 3 North Bay, ON Mr. David Pilkey Tel: 705 693-1363	✓	✓				✓	✓							✓	✓			

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75μm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Pioneer Construction Inc. – Mobile B4/C4 Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. – Mobile C-2 Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓				✓	✓							✓	✓			
Pioneer Construction Inc. – Thunder Bay Sault Ste. Marie, ON Ms. S. Geiling Tel: 705 541-2280	✓	✓		✓		✓	✓							✓	✓			
Pioneer Construction Inc. – West Main Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Precision Age Aggregate Testing Ltd. Thunder Bay, ON Mr. W. Werbowetski Tel: 807 577-3927								✓	✓									
Preston Sand & Gravel Kitchener, ON Mr. M. Bell Tel: 519 579-1248	✓	✓				✓	✓							✓				
R. W. Tomlinson Limited Gloucester, ON Mr. B. Hendriks Tel: 613 822-1867	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓		✓	✓
Regional Municipality of Durham, Materials Testing Division, Whitby, ON Mr. Joeman Ng Tel: 905 655-3344	✓	✓		✓		✓	✓							✓	✓			
Royel Paving Limited Mobile 1 Lindsay, ON Mr. J. Simmons Tel: 705 324-6773	✓	✓				✓	✓							✓	✓			
Sarafinchin Associates Ltd. Rexdale, ON Mr. S. Jeffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaba Testing Services Limited Chaput Hughes, ON Mr. L. Shaba Tel: 705 567-4187	✓	✓				✓								✓	✓			
Shaheen & Peaker Limited Toronto, ON Mr. A. Mendonca Tel: 416 213-1255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen & Peaker Limited (Geo-Canada) Markham, ON Mr. S. Peaker Tel: 905 474-9255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen Peaker Thompson Limited Oshawa ON Mr. D. Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
Site Investigation Services, Division of Jagger Hims Ltd, Peterborough, ON Mr. S. Ash Tel: 705 743-6850	✓	✓				✓								✓				
Smelter Bay Aggregates Inc. Thessalon, ON Mr. C. Hernden Tel: 705 842-3908	✓	✓				✓	✓							✓				
Smith's Construction - Mobile 8660 Arnprior, ON Mr. Frank Gainer Tel: 613 623-3144	✓	✓				✓	✓							✓	✓			

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Smith's Construction – Mobile EO50612 Arnprior, ON Mr. Frank Gainer Tel: 613 623-3144	✓	✓				✓	✓							✓	✓			
Smith's Construction- Mobile 60853 Arnprior, ON Mr. Frank Gainer Tel: 613 623-3144	✓	✓				✓	✓							✓	✓			
Soil-Eng Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✓	✓				✓	✓							✓	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. G. McIntee Tel: 613 938-2521	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Steed and Evans Limited Heidelberg, ON Mr. R. Marco Tel: 519 699-4646	✓	✓				✓	✓							✓				
Sutcliffe Rody Quesnel Limited New Liskeard, ON Mr. Dan Cook Tel: 705 647-4311	✓	✓				✓	✓								✓			
Sutton and Associates Smithville, ON Mr. K. MacDonald Tel: 905 957-6893	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Teranorth Construction & Engineering Limited, Sudbury, ON Mr. James Bot Tel: 705 523-1540	✓	✓				✓	✓							✓	✓			
Terraprobe Limited Brampton, ON Ms. Valerie Rose Tel: 905 796-2650	✓	✓		✓		✓	✓	✓						✓	✓	✓	✓	✓
Terraprobe Limited Barrie, ON Mr. B. Jackson Tel: 705 739-8355	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Limited (Mountainview) Stoney Creek, ON Mr. G. Muckle Tel: 905 643-7560	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Terraprobe Limited Sudbury Sudbury, ON Mr. R. Carniello Tel: 705 670-0460	✓	✓				✓								✓	✓	✓	✓	
Terraspec Engineering Peterborough, ON Mr. S. Galloway Tel: 705 743-7880	✓	✓				✓								✓	✓	✓	✓	✓
The Miller Group–Materials Research Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	
The Murray Group Moorefield, ON Mr. Chris Hodgson Tel: 519 638-3077	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. P. White Tel: 613 259-2670	✓	✓				✓								✓				
Thunder Bay Testing and Engineering Thunder Bay, ON Mr. T. Fummerton Tel: 807 624-5162	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓

2005 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
Thurber Engineering Limited Oakville, ON Dr. P. K. Chatterji Tel: 905 829-8666	✓	✓				✓								✓	✓	✓	✓	✓
Trow Consulting Engineers Limited Brampton, ON Mr. S. Lee Tel: 905 793-9800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trow Consulting Engineers Limited London, ON Ms. R. Walker Tel: 519 453-1480	✓	✓				✓								✓	✓			
Trow Consulting Engineers Limited Stoney Creek, ON Mr. C. Douglas Tel: 905 664-3300	✓	✓				✓								✓				
Trow Consulting Engineers Limited Sudbury, ON Mr. R. Ferguson Tel: 705 674-9681	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Trow Consulting Engineers Ltd. Nepean, ON Mr. I.M. Taki Tel: 613 225-9940	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Trow Consulting Engineers Ltd. Thunder Bay, ON Mr. K. Mosley Tel: 807 623-9495	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	
Trow Consulting Engineers Ltd. Barrie, ON Mr. L. Knegt Tel: 705 734-6222	✓	✓				✓	✓							✓	✓			
Vicdom Sand and Gravel Ltd. Uxbridge, ON Mr. B. Giordano Tel: 905 649-2193	✓	✓				✓	✓							✓				
Walker Brothers Quarries Limited Thorold, ON Mr. Tom Risi Tel: 905 680-3750	✓	✓		✓		✓	✓				✓	✓		✓				

Appendix B2: List of Participants

2005 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4719 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AME -Materials Engineering – East Brampton, ON Mr. B. Dobson Tel: 905 640-7772	✓	✓	✓	✓
AME -Materials Engineering – Main Brampton, ON Mr. S. Crowley Tel: 905 840-5914	✓	✓	✓	✓
AMEC Earth & Environmental Limited Hamilton, ON Mr. J. Balinski Tel: 905 312-0700	✓	✓	✓	✓
AMEC Earth & Environmental Limited Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓	✓	✓
Bruno's Contacting (Thunder Bay) Limited – No. 376 Thunder Bay, ON Mr. B. Prevost Tel: 807 623-1855	✓	✓	✓	✓
Construction Testing Asphalt Lab Oakville, ON Mr. P. Lung Tel: 905 469-6352	✓	✓	✓	✓
DBA Engineering Limited Kingston, ON Mr. M. McClelland Tel: 613 389-1781	✓	✓	✓	✓
DBA Engineering Limited - Main Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓	✓	✓
DST Consulting Engineers Inc. Thunder Bay, ON Mr. Scott Tozer Tel: 807 623-2929	✓	✓	✓	✓
Dufferin Aggregates – Milton Lab Milton, ON Maurice Guimont Tel: 416 796-4772	✓	✓	✓	✓
Dufferin Construction Ltd. (QC) – Bronte Lab Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓	✓	✓
Dufferin Construction Ltd. Mobile Lab No. 1 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓	✓	✓
Fowler Construction Company Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓	✓	✓
Fowler Construction Company Mobile 1 Bracebridge, ON Mr. J. Gordon Tel: 705 645-2214	✓	✓	✓	✓
Geo-Logic Inc. Peterborough, ON Mr. W. Rayfuse Tel: 705 749-3317	✓	✓	✓	✓
Golder Associates Ltd. London, ON Mr. C. Sewell Tel: 519 652-0099	✓	✓	✓	✓
Golder Associates Ltd. Sudbury, ON Ms. Tina Nantel Tel: 705 524-6861	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. J. Watkins Tel: 905 723-2727	✓	✓	✓	✓
Graham Bros. Construction Limited Brampton, ON Mr. G. Thompson Tel: 905 453-1200	✓	✓	✓	✓

2005 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4719 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Hard Rock Paving Company Limited Port Colborne, ON Ms. J. Koros Tel: 905 834-4581			✓	✓
Harold Sutherland Construction Limited Kemble, ON Mr. R. Leigh Tel: 519 376-0603	✓	✓	✓	✓
Jacques Whitford Limited Ottawa, ON Mr. B. Prevost Tel: 613 738-0708	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. Shawn Nelson Tel: 705 472-5331	✓	✓	✓	✓
John Emery Geotechnical Engineering Limited Etobicoke, ON Mr. Dawit Amar Tel: 416 213-1060	✓	✓	✓	✓
K.J. Beamish Construction King City, ON Mr. C. Henderson Tel: 905 833-4666	✓	✓	✓	✓
Karson Kartage & Konstruction Stittsville, ON Mr. C. MacDonald Tel: 613 831-0717	✓	✓	✓	✓
Lafarge Canada Inc. – Fonthill Lab Fonthill, ON Mr. J. Vingerhoets Tel: 905 892-2686			✓	✓
Lafarge Canada Inc. – Hamilton Lab Hamilton, ON Mr. Chris Thomas Tel: 905 522-7735	✓		✓	✓
Lafarge Canada Inc. – Research Lab Mississauga, ON Mr. Paul Lum Tel: 905 819-1290	✓	✓	✓	✓
Lafarge Paving & Construction (Eastern) Ltd. Belleville, ON Mr. Gary Bates Tel: 613 962-2461	✓	✓	✓	✓
Lafarge Paving & Construction (Eastern) Ltd. Toronto, ON Mr. Andrew Pahalan Tel: 416 633-9670	✓	✓	✓	✓
Lafarge Paving & Construction Ltd. London, ON Mr. Shawn Dietze Tel: 519 451-2750	✓	✓	✓	✓
McAsphalt Engineering Services Toronto, ON Mr. K. Davidson Tel: 416 282-8181	✓	✓	✓	✓
Mill-Am Corporation – Lab No. 890901 Oldcastle, ON Mr. H. Villlneff Sr. Tel: 519 945-7441	✓	✓	✓	✓
Miller Northwest – Mobile No. 87526 Dryden, ON Mr. H. Villlneff Sr. Tel: 807 223-2844	✓	✓	✓	✓
Miller Northwest – Mobile 1 Dryden, ON Mr. H. Villlneff Sr. Tel: 807 223-2844	✓	✓	✓	✓
Miller Paving Limited - Markham Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓	✓	✓
Miller Paving Northern – Mobile No. 1084 North Bay, ON Mr. H. Villneff Sr. Tel: 705 267-1107	✓	✓	✓	✓
Miller Paving Northern – Mobile No. 1254 New Liskeard, ON Mr. H. Villneff Sr. Tel: 705 647-4331	✓	✓	✓	✓
Ministry of Transportation Downsview, ON Mr. C. Rogers Tel: 416 235-3734	✓	✓	✓	✓
Peto MacCallum Ltd. Hamilton, ON Mr. E.L. Truax Tel: 905 561-2231	✓	✓	✓	✓

2005 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program Contact Chris Rogers at (416) 235-3734	ASTM D 1252/AASHTO T 304 - Uncompacted Void Content of Fine Aggregate	ASTM D 4219/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4719 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Peto MacCallum Ltd. Kitchener, ON Mr. T. Smith Tel: 519 893-7500	✓	✓	✓	✓
Peto MacCallum Ltd. Toronto, ON Mr. A. Nathoo Tel: 416 785-5110	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, ON Mrs. S. Geiling Tel: 705 541-2280	✓	✓	✓	✓
Pioneer Construction Inc. - Main Lab Sudbury, ON Mr. David Pilkey Tel: 705 560-7200	✓	✓	✓	✓
R. W. Tomlinson Limited Gloucester, ON Mr. B. Hendriks Tel: 613 822-1867	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. G. McIntee Tel: 613 938-2521	✓	✓	✓	✓
Terraprobe Limited Brampton, ON Ms. Valerie Rose Tel: 905 796-2650	✓	✓	✓	✓
The Miller Group – Materials Research Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓	✓	✓
Thunder Bay Testing and Engineering Ltd. Thunder Bay, ON Mr. T. Fummerton Tel: 807 624-5162	✓	✓	✓	✓
Trow Consulting Engineers Limited Brampton, ON Mr. S. Lee Tel: 905 793-9800	✓	✓	✓	✓
Trow Consulting Engineers Limited Nepean, ON Mr. I. M. Taki Tel: 613 225-9940	✓	✓	✓	✓
Trow Consulting Engineers Limited Sudbury, ON Mr. R. Ferguson Tel: 705 674-9681	✓	✓	✓	✓
Walker Brothers Quarries Thorold, ON Mr. Tom Risi Tel: 905 680-3750	✓		✓	✓

Appendix C: Multi-Laboratory Precision

Test 1	2002		2003		2004		2005		ASTM C117
WP 75 μm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	0.89	0.86	1.09	1.22	1.01	1.03	1.18	1.16	<1.5
1S	0.22	0.19	0.30	0.28	0.15	0.13	0.23	0.26	0.22
D2S	0.62	0.54	0.85	0.80	0.43	0.37	0.65	0.73	0.62
n/Outliers	192/16		197/6		197/6		192/12		

Test 8	2002		2003		2004		2005		ASTM C131	
L. L. A	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	C of V	σ^*
Mean	24.20	24.27	23.70	24.36	21.54	21.27	23.44	23.19	10-45	23.3
1S	1.68	0.87	2.07	1.39	0.91	1.45	1.08	1.41	4.5%	1.05
D2S	4.75	2.45	5.87	3.94	2.57	4.09	3.05	3.97	12.7%	2.96
n/Outliers	11/2		11/1		9/2		11/0			

Test 9	2002		2003		2004		2005		ASTM C127
RD (O.D)	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	2.671	2.670	2.669	2.668	2.687	2.686	2.660	2.660	
1S	0.008	0.007	0.007	0.007	0.006	0.006	0.007	0.009	0.013
D2S	0.023	0.020	0.020	0.020	0.017	0.017	0.020	0.025	0.038
n/Outliers	81/9		86/3		89/6		92/5		

Test 10	2002		2003		2004		2005		ASTM C127 - 88
ABS	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	0.675	0.666	0.697	0.710	0.463	0.470	1.544	1.549	< 2%
1S	0.076	0.079	0.079	0.078	0.064	0.073	0.143	0.167	0.145
D2S	0.215	0.223	0.223	0.221	0.181	0.206	0.403	0.471	0.41
n/Outliers	86/4		87/2		91/4		93/4		

Test 11	2002		2003		2004		2005		ASTM C88	
MgSO4	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	C of V	σ^*
Mean	12.5	12.8	13.8	13.8	5.4	5.2	13.6	13.5	9-20%	13.6
1S	3.0	3.2	3.4	3.0	2.0	1.7	3.4	3.0	25%	3.39
D2S	8.5	9.0	9.7	8.5	5.7	4.7	9.5	8.4	71%	9.6
n/Outliers	35/0		34/1		34/1		31/1			

Test 12	2002		2003		2004		2005		MTO Workshop
% Crush	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	70.0	70.2	64.3	64.7	69.2	69.7	68.7	69.1	50 - 75
1S	5.3	5.6	5.4	5.8	4.7	4.9	5.3	5.6	6.0%
D2S	15.0	15.8	15.4	16.5	13.5	13.9	14.8	15.8	16.9%
n/Outliers	186/22		197/5		188/15		201/3		

Test 13	2002		2003		2004		2005		ASTM D 4791
% F & E	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	3.4	3.1	3.8	3.6	9.2	8.9	6.5	6.2	No ASTM Precision Statements for this test
1S	1.8	1.6	2.6	2.2	3.7	3.5	3.0	2.7	
D2S	5.1	4.5	7.3	6.2	10.5	9.9	8.5	7.8	
n/Outliers	145/19		158/4		160/7		162/6		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 14	2002		2003		2004		2005		ASTM
PN Conc.	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	Analysis Not Done		Analysis Not Done		150.9	145.3	Analysis Not Done		No ASTM Standard for this Test.
1S					6.9	12.3			
D2S					19.6	34.9			
n/Outliers					20/6				

Test 16	2002		2003		2004		2005		MTO LS - 618
MDA, CA	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	19.16	18.97	19.18	19.07	10.53	10.53	11.49	11.43	12
1S	0.95	0.93	1.01	0.95	0.53	0.53	0.61	0.72	0.77
D2S	2.69	2.63	2.85	2.68	1.51	1.51	1.73	2.04	2.17
n/Outliers	62/4		62/1		58/4		61/4		

Test 17	2002		2003		2004		2005		MTO LS - 614
Freeze-thaw	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	15.64	15.44	15.93	16.06	17.46	17.65	14.59	14.77	19
1S	4.41	3.93	3.44	2.95	3.72	3.77	2.95	3.16	1.7
D2S	12.48	11.13	9.73	8.36	10.53	10.68	8.31	8.92	4.9
n/Outliers	50/2		45/3		47/1		47/3		

Test 2	2002		2003		2004		2005		ASTM C136^A
P 19.0 mm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	98.4	98.4	99.0	99.0	97.7	97.6	92.8	91.8	100 - 95
1S	0.5	0.5	0.3	0.3	0.5	0.6	1.1	1.1	0.35
D2S	1.4	1.4	0.9	0.9	1.5	1.8	3.1	3.2	1.0
n/Outliers	208/3		198/6		203/1		206/0		

Test 3	2002		2003		2004		2005		ASTM C136^A
P 16.0 mm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	92.7	92.8	94.6	94.5	89.5	89.0	84.6	82.9	95 - 85
1S	0.9	0.9	0.8	0.7	1.3	1.4	1.3	1.4	1.37
D2S	2.7	2.5	2.2	2.2	3.6	3.9	3.6	4.1	3.9
n/Outliers	205/6		202/2		203/1		204/2		

Test 4	2002		2003		2004		2005		ASTM C136^A
P 13.2 mm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	86.5	86.6	88.0	87.8	79.8	78.9	77.5	75.4	80 – 60
1S	1.4	1.1	1.1	1.1	1.8	2.1	1.4	1.5	2.82
D2S	3.9	3.1	3.2	3.2	5.2	5.9	4.1	4.1	8.0
n/Outliers	204/7		201/3		203/1		204/2		

Test 5	2002		2003		2004		2005		ASTM C136^A
P 9.5 mm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	72.6	71.5	74.9	74.8	64.8	63.6	66.2	63.8	80 – 60
1S	1.9	1.6	1.2	1.3	2.0	2.5	1.5	1.6	2.82
D2S	5.4	4.4	3.4	3.7	5.6	7.1	4.2	4.4	8.0
n/Outliers	200/11		200/4		201/3		204/2		

Test 6	2002		2003		2004		2005		ASTM C136^A
P 4.75 mm	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	48.5	44.7	55.7	56.1	47.5	46.6	49.9	47.8	60 – 20
1S	2.7	2.2	1.4	1.5	1.9	2.4	1.4	1.6	1.97
D2S	7.8	6.4	4.0	4.3	5.5	6.7	3.9	4.4	5.6
n/Outliers	205/6		198/5		203/1		203/3		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2002		2003		2004		2005		ASTM C136^A
P 2.36 mm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	40.1	36.6	42.4	43.1	37.2	36.4	37.4	36.2	60 – 20
1S	2.8	2.5	1.9	2.1	1.9	2.1	1.7	1.8	1.41
D2S	8.0	7.2	5.3	5.8	5.6	5.8	4.9	5.0	4.0
n/Outliers	205/6		202/2		202/2		205/1		

Test 21	2002		2003		2004		2005		ASTM C136^A
P 1.18 mm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	32.9	29.8	30.8	32.1	28.4	27.9	25.7	25.0	60 – 20
1S	2.7	2.3	2.1	2.0	1.9	2.0	1.5	1.7	1.41
D2S	7.6	6.6	5.9	5.7	5.3	5.6	4.3	4.9	4.0
n/Outliers	205/6		202/2		202/2		205/1		

Test 22	2002		2003		2004		2005		ASTM C136^A
P 600 µm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	24.2	21.9	22.7	24.2	19.7	19.4	17.0	16.6	20 – 15
1S	2.3	1.9	1.8	1.7	1.5	1.7	1.1	1.3	1. 01
D2S	6.5	5.4	5.0	4.9	4.3	4.9	3.2	3.7	3.10
n/Outliers	203/8		202/2		203/1		204/2		

Test 23	2002		2003		2004		2005		ASTM C136^A
P 300 µm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	13.6	12.4	17.1	18.2	12.2	12.0	11.9	11.6	15 – 10
1S	1.4	1.3	1.3	1.2	1.1	1.2	0.8	0.9	0.73
D2S	4.0	3.7	3.8	3.5	3.0	3.5	2.4	2.7	2.10
n/Outliers	202/9		201/3		204/0		204/2		

Test 24	2002		2003		2004		2005		ASTM C136^A
P 150 µm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	4.9	4.5	12.6	13.3	8.3	8.1	9.4	9.2	10 – 2
1S	0.6	0.6	0.9	0.8	0.7	0.9	0.7	0.7	0.65
D2S	1.6	1.7	2.6	2.3	2.1	2.6	1.9	1.9	1.8
n/Outliers	201/10		200/4		203/1		202/4		

Test 25	2002		2003		2004		2005		ASTM C136^A
P 75 µm	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	1.8	1.8	9.2	9.6	6.3	6.1	7.8	7.6	10 – 2
1S	0.2	0.3	0.6	0.6	0.6	0.7	0.6	0.6	0.65
D2S	0.7	0.8	1.7	1.7	1.7	2.1	1.7	1.7	1.8
n/Outliers	204/7		200/4		202/2		203/3		

Test 27	2002		2003		2004		2005		ASTM C 128
RD (O.D)	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	2.718	2.717	2.654	2.656	2.602	2.600	2.593	2.501	
1S	0.015	0.013	0.012	0.012	0.015	0.019	0.017	0.045	0.023
D2S	0.042	0.037	0.034	0.034	0.042	0.054	0.048	0.127	0.066
n/Outliers	77/9		77/10		82/11		87/8		

Test 28	2002		2003		2004		2005		ASTM C 128
ABS	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	0.95	0.97	0.85	0.82	1.717	1.719	1.713	3.109	< 1.0%
1S	0.18	0.19	0.20	0.15	0.19	0.30	0.30	0.78	0.23
D2S	0.52	0.54	0.58	0.43	0.56	0.85	0.86	2.20	0.66
n/Outliers	81/5		78/9		83/10		91/4		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 29	2002		2003		2004		2005		ASTM C88
MgSO4	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	7.4	7.3	14.4	14.1	11.9	11.9	17.3	17.0	ASTM precision Statements for Coarse Aggregate only
1S	3.2	2.8	4.4	4.6	4.5	4.5	3.6	3.9	
D2S	9.2	8.0	12.6	13.0	12.9	12.9	10.0	10.9	
n/Outliers	31/0		32/0		33/0		29/2		

Test 30	2002		2003		2004		2005		MTO LS-621
% ACP	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	28.1	41.8	39.3	38.9	41.3	40.6	39.4	40.1	No MTO precision statements for this test
1S	2.7	5.4	5.2	4.7	4.9	4.4	3.6	3.1	
D2S	7.6	15.2	14.7	13.3	14.0	12.6	10.2	8.8	
n/Outliers	202/7		195/5		196/6		188/14		

Test 31	2002		2003		2004		2005		MTO LS-623
MWD	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	2.146	2.153	2.409	2.407	2.280	2.281	2.308	2.306	No MTO precision statements for this test
1S	0.028	0.030	0.044	0.051	0.029	0.041	0.037	0.040	
D2S	0.079	0.085	0.124	0.144	0.082	0.116	0.104	0.112	
n/Outliers	130/14		134/4		133/8		143/4		

Test 32	2002		2003		2004		2005		MTO LS-623
MDD	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	1.941	1.949	2.252	2.251	2.102	2.105	2.134	2.133	No MTO precision statements for this test
1S	0.032	0.032	0.049	0.052	0.033	0.040	0.045	0.051	
D2S	0.090	0.090	0.138	0.147	0.093	0.113	0.127	0.144	
n/Outliers	133/11		134/4		136/5		147/0		

Test 33	2002		2003		2004		2005		MTO LS-623
OMC	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	10.63	10.53	7.13	7.15	8.47	8.48	8.16	8.20	No MTO precision statements for this test
1S	0.52	0.54	0.44	0.45	0.45	0.49	0.47	0.52	
D2S	1.47	1.53	1.25	1.28	1.28	1.39	1.33	1.46	
n/Outliers	136/8		136/2		141/0		144/3		

Test 34	2002		2003		2004		2005		MTO LS-619
MDA, FA3	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	13.7	13.8	15.1	15.1	16.6	16.7	15.3	15.4	19.0
1S	1.3	1.2	1.1	1.1	1.5	1.4	1.1	1.1	1.06
D2S	3.7	3.4	3.2	3.0	4.1	4.1	2.3	3.1	3.0
n/Outliers	61/2		61/3		61/1		62/3		

Test 40	2002		2003		2004		2005		MTO LS-702
P 2.0 mm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	100.0	99.9	100.0	100.0	100.0	100.0	99.9	99.9	No MTO precision statements for this test
1S		0.05							
D2S		0.13							
n/Outliers	60/16		57/8		67/0		67/0		

Test 41	2002		2003		2004		2005		MTO LS-702
P 425 μm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	98.3	96.3	98.3	98.3	97.1	97.0	96.5	96.5	No MTO precision statements for this test
1S	0.5	0.5	0.5	0.4	0.6	0.6	0.3	0.4	
D2S	1.4	1.3	1.4	1.1	1.7	1.7	1.0	1.1	
n/Outliers	60/15		61/4		60/7		59/8		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 42	2002		2003		2004		2005		MTO LS-702
P 75 µm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	92.5	88.6	92.5	92.5	91.7	91.7	88.7	88.8	No MTO precision statements for this test
1S	0.7	0.4	0.9	0.8	0.9	0.8	0.6	0.5	
D2S	2.1	1.1	2.5	2.2	2.7	2.4	1.6	1.5	
n/Outliers	58/17		59/6		59/8		63/4		

Test 43	2002		2003		2004		2005		MTO LS-702
P 20 µm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	63.5	70.2	63.5	62.3	78.1	78.5	71.0	70.3	No MTO precision statements for this test
1S	3.8	4.0	5.4	4.3	3.3	3.8	4.8	4.1	
D2S	10.7	11.5	15.3	12.3	9.5	10.8	13.6	11.6	
n/Outliers	66/9		61/4		60/7		65/2		

Test 44	2002		2003		2004		2005		MTO LS-702
P 5 µm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	45.0	44.7	45.8	45.1	59.0	58.8	44.0	43.8	No MTO precision statements for this test
1S	3.5	3.0	4.1	4.1	4.3	3.8	3.7	3.3	
D2S	10.0	8.6	11.7	11.6	12.1	10.7	10.6	9.3	
n/Outliers	66/9		62/3		62/5		64/3		

Test 45	2002		2003		2004		2005		MTO LS-702
P 2 µm	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	33.4	31.1	35.4	34.7	44.4	44.6	30.5	30.5	No MTO precision statements for this test
1S	3.7	3.4	4.5	4.3	2.8	2.7	3.1	3.0	
D2S	10.6	9.5	12.9	12.1	7.9	7.7	8.8	8.6	
n/Outliers	67/8		63/2		57/10		65/2		

Test 46	2002		2003		2004		2005		ASTM D 4318
L. L	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	34.1	27.4	34.0	33.8	36.9	37.2	27.7	27.6	33.3
1S	2.8	1.6	2.2	1.9	1.8	1.7	1.4	1.5	0.8
D2S	7.92	4.47	6.3	5.5	5.0	4.9	4.0	4.1	2
n/Outliers	73/5		77/1		75/2		73/4		

Test 47	2002		2003		2004		2005		ASTM D 4318
P. L	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	17.8	15.5	17.6	17.6	19.3	19.2	15.6	15.5	19.9
1S	1.65	1.24	1.92	1.78	1.4	1.4	1.3	1.5	1.3
D2S	4.68	3.52	5.4	5.0	3.9	4.0	3.7	4.4	4
n/Outliers	72/6		77/1		74/3		75/2		

Test 48	2002		2003		2004		2005		ASTM D 4318
P. I	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	16.2	11.9	16.1	16.0	17.5	18.0	12.3	12.3	13.4
1S	2.93	1.42	2.71	2.67	2.1	2.3	1.7	1.8	1.6
D2S	8.30	4.01	7.66	7.56	6.1	6.4	4.7	5.2	4
n/Outliers	73/5		78/0		76/1		77/0		

Test 49	2002		2003		2004		2005		AASHTO T 100
SG of Soils	5.02	6.02	5.03	6.03	5.04	6.04	5.05	6.05	
Mean	2.713	2.732	2.703	2.699	2.729	2.733	2.729	2.728	
1S	0.035	0.026	0.041	0.042	0.029	0.029	0.027	0.030	0.04
D2S	0.099	0.073	0.116	0.118	0.082	0.082	0.076	0.085	0.11
n/Outliers	56/9		58/0		50/10		52/6		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2002		2003		2004		2005		ASTM C 1252
UC Void	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	42.81	42.72	41.64	42.12	42.09	41.81	41.19	40.33	ASTM C 1252^A
1S	0.84	0.64	1.62	1.35	1.48	1.11	1.45	1.39	0.33%
D2S	2.38	1.81	4.58	3.83	4.19	3.15	4.08	3.91	0.93%
n/Outliers	18/2		28/4		35/6		50/1		

Test 96	2002		2003		2004		2005		ASTM D 2419
SE Value	3.02	4.02	3.03	4.03	3.04	4.04	3.05	4.05	
Mean	90.11	89.52	31.15	31.19	49.9	50.6	30.7	30.0	< 80
1S	2.62	2.02	3.51	2.80	8.08	8.60	3.74	2.82	8.0
D2S	7.41	5.72	9.93	7.92	22.88	24.30	10.54	7.95	22.6
n/Outliers	18/0		28/1		38/0		42/7		

Test 97	2002		2003		2004		2005		ASTM D 5821
% Fractured	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	71.34	72.39	66.12	67.07	71.18	71.51	71.28	70.54	76.0%
1S	4.19	4.95	6.78	6.65	5.02	5.01	5.02	5.24	5.2%
D2S	11.86	14.01	19.19	18.82	14.20	14.18	14.17	14.77	14.7%
n/Outliers	20/0		32/1		42/0		53/0		

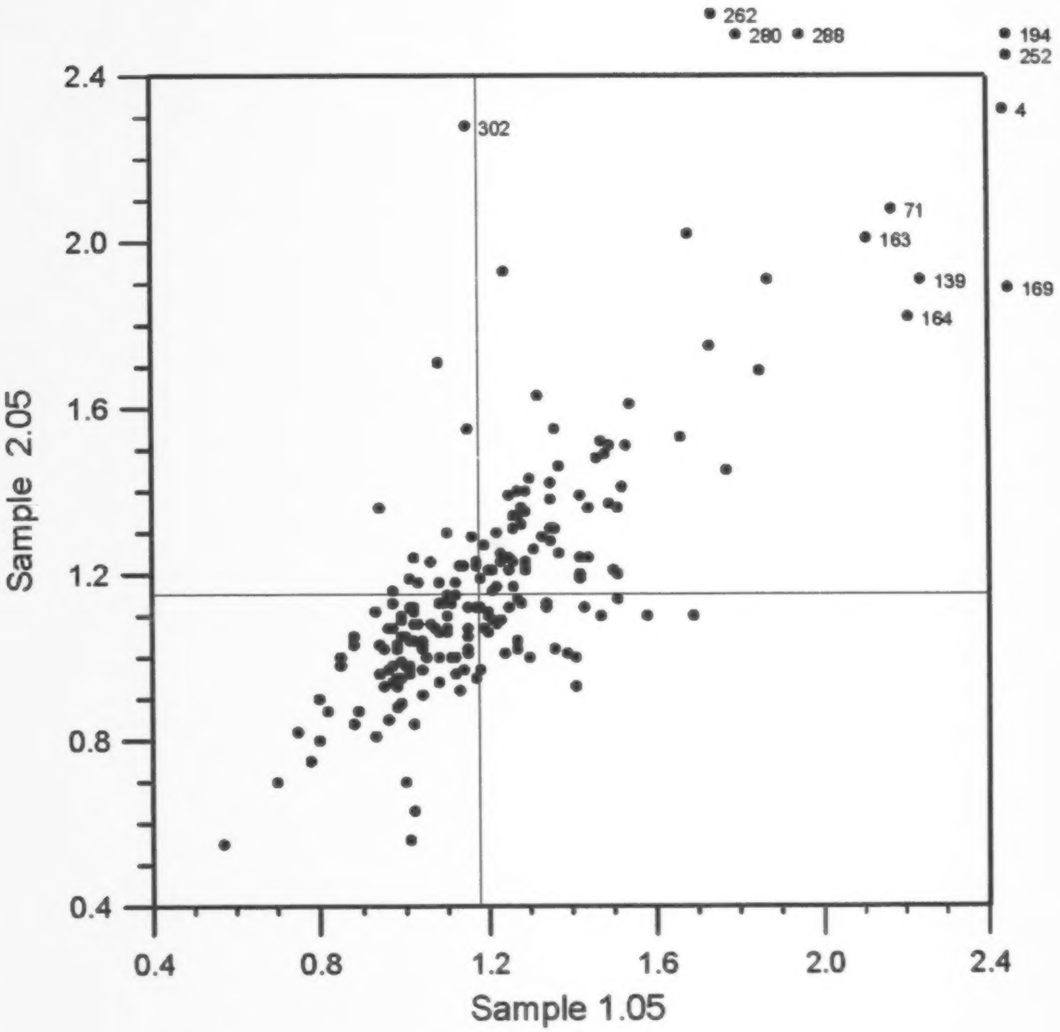
Test 99	2002		2003		2004		2005		AST D 4791
% F & E	1.02	2.02	1.03	2.03	1.04	2.04	1.05	2.05	
Mean	0.59	0.48	0.46	0.38	1.75	1.61	1.14	1.18	No ASTM precision statements for this test
1S	0.62	0.53	0.52	0.42	1.12	0.93	0.69	0.67	
D2S	1.75	1.50	1.47	1.19	3.13	2.64	1.94	1.89	
n/Outliers	19/1		32/2		40/2		46/7		

Test 123	2004		2005		2006		2007		ASTM C 1260
Mortar Bar	1.04	2.04	1.05	2.05	1.06	2.06	1.07	2.07	
Mean	0.196	0.410	Not Conducted						Expansion>0.1%
1S	0.035	0.051							15.2%
D2S	0.099	0.144							43 %
n/Outliers	16/0								

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams



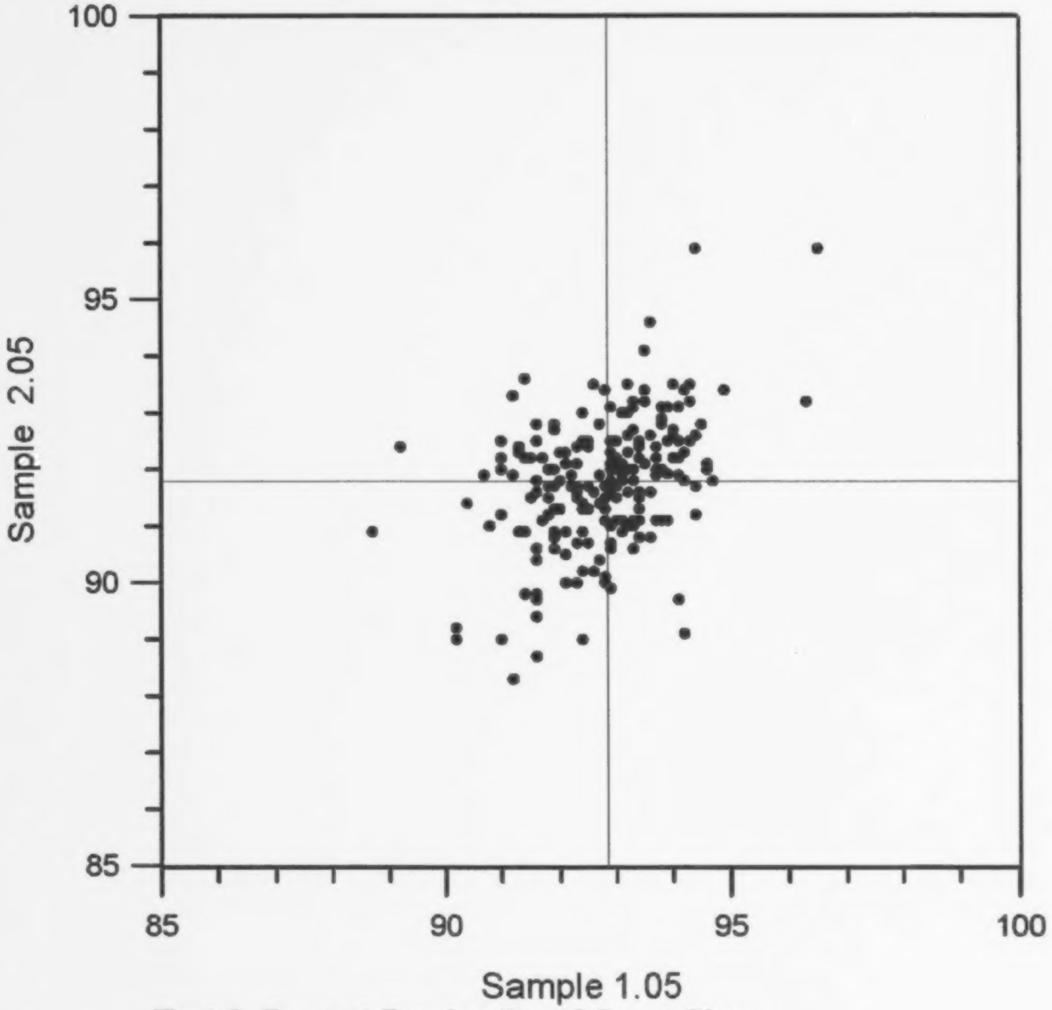
Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	1.186	1.165
Median	1.220	1.285
Std Dev	0.229	0.258

n = 192

Labs Eliminated: 4, 71, 139, 163, 164, 169, 194, 252, 262, 280, 288, 302

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



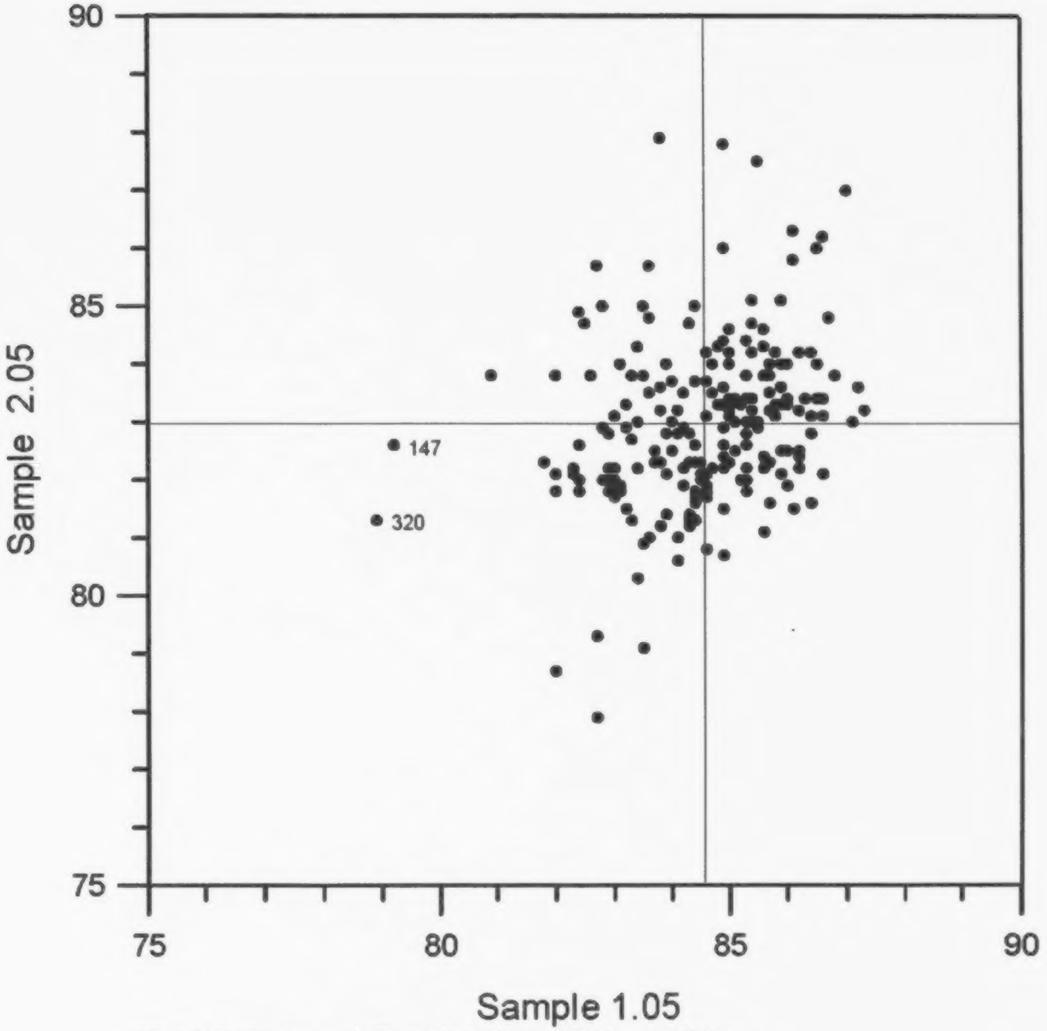
Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	92.767	91.772
Median	92.600	92.100
Std Dev	1.118	1.137

n = 206

Lab Eliminated: None

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

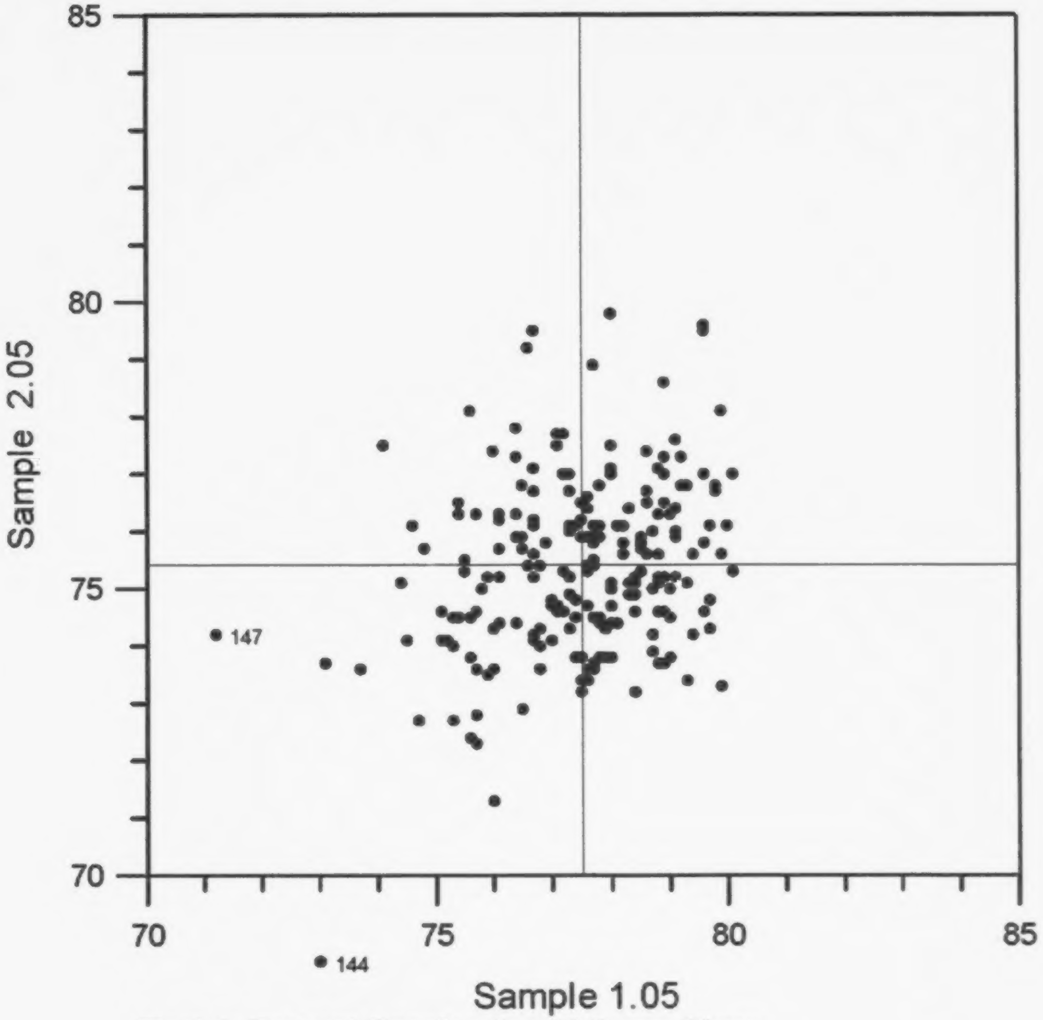


Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	84.618	82.964
Median	84.100	82.900
Std Dev	1.284	1.444
n = 204		

Lab Eliminated: 147, 320

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

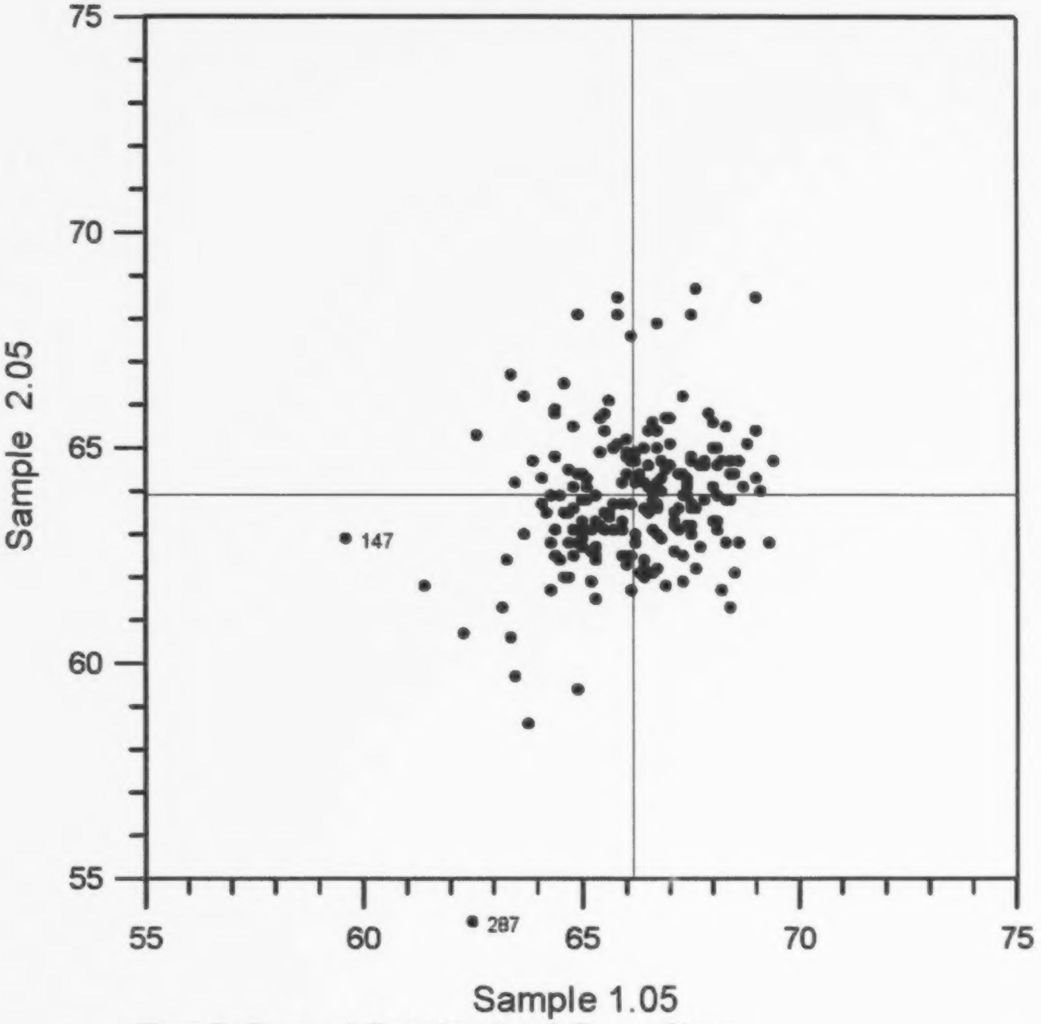


Test 4: Percent Passing the 13.2 mm Sieve

	Mat 1	Mat 2
Mean	77.500	75.399
Median	76.600	75.550
Std Dev	1.440	1.472
n = 204		

Lab Eliminated: 144, 147

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

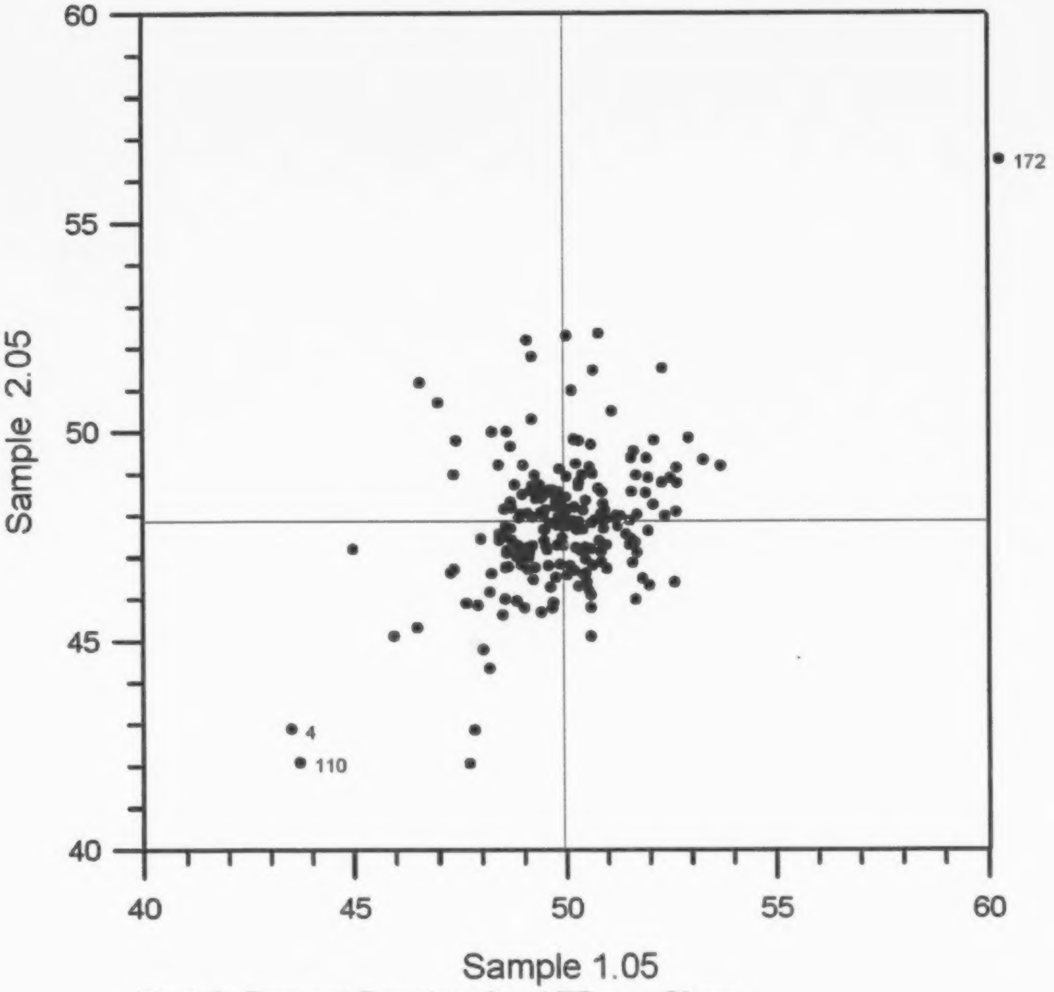


Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	66.226	63.854
Median	65.400	63.650
Std Dev	1.498	1.571
n = 204		

Labs Eliminated: 147, 287

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



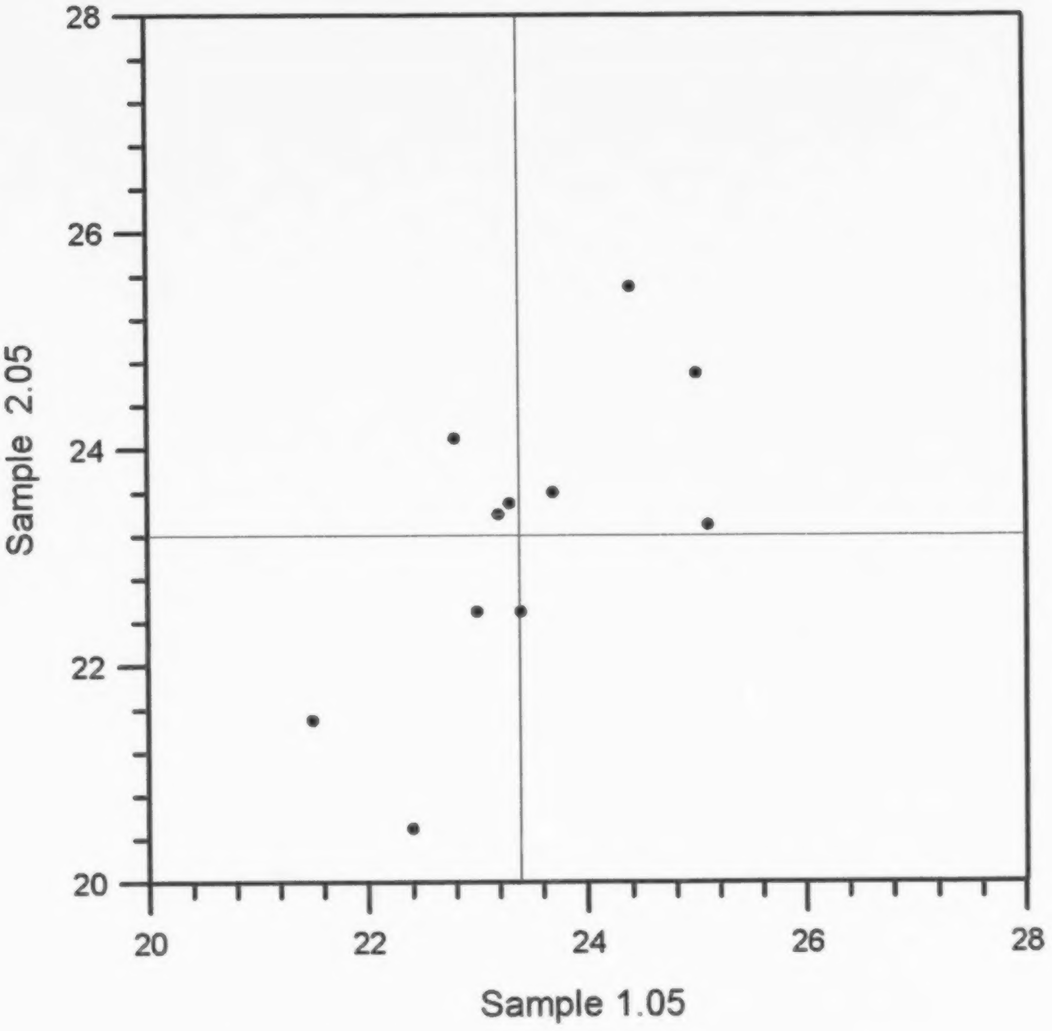
Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	49.927	47.779
Median	49.350	47.215
Std Dev	1.386	1.562

n = 203

Lab Eliminated: 4, 110, 172

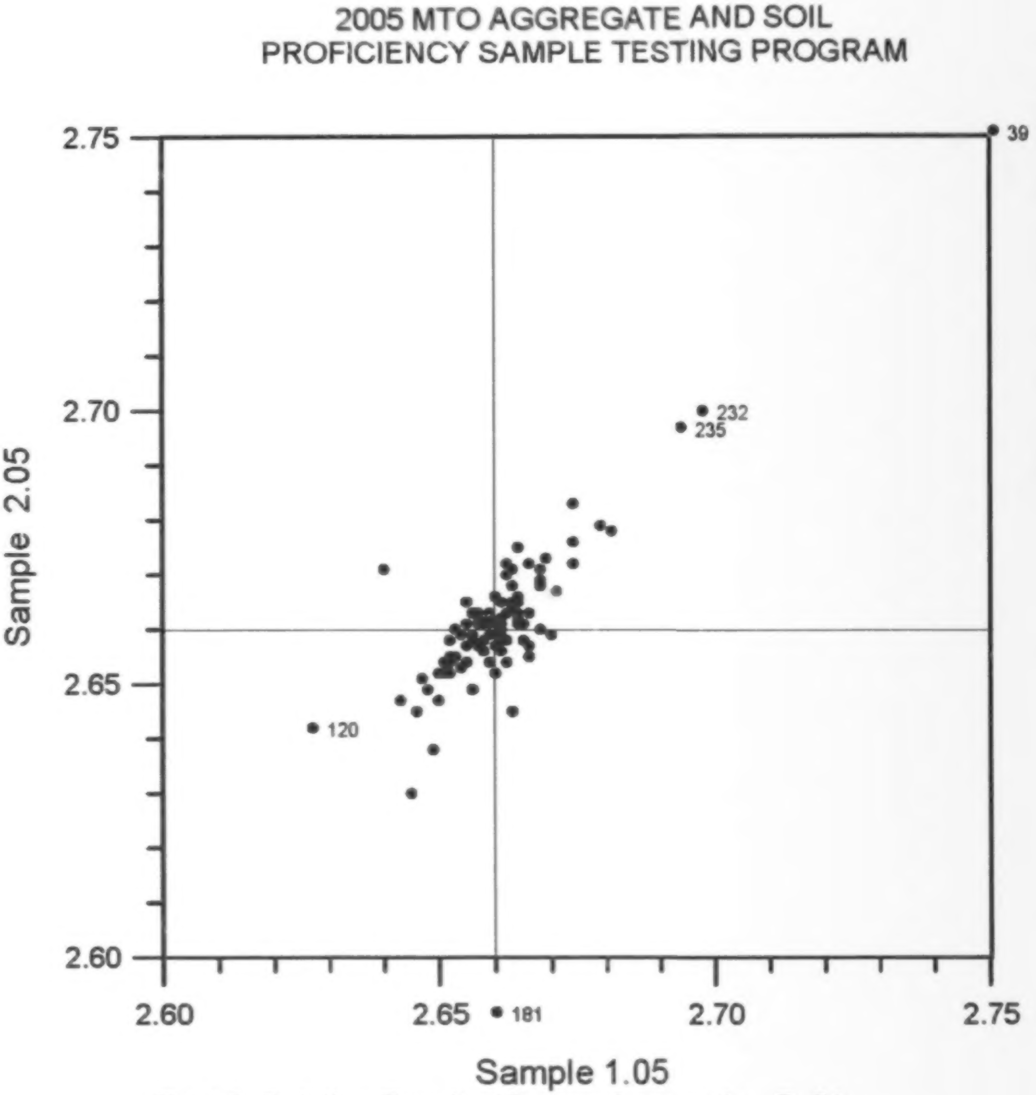
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	23.436	23.191
Median	23.300	23.000
Std Dev	1.082	1.407
n = 11		

Labs Eliminated: None



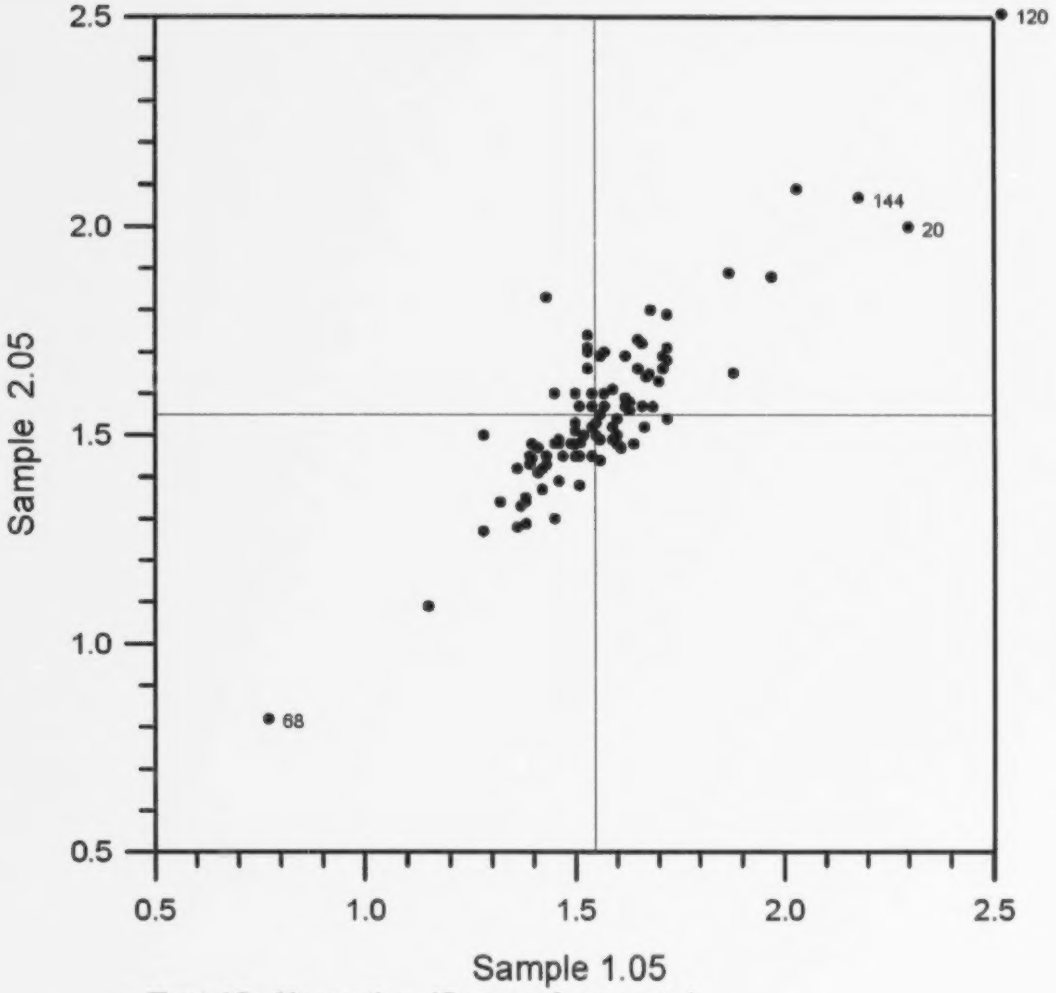
Test 9: Relative Density (Coarse Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.660	2.660
Median	2.661	2.657
Std Dev	0.007	0.009

n = 92

Labs Eliminated: 39, 120, 181, 232, 235

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

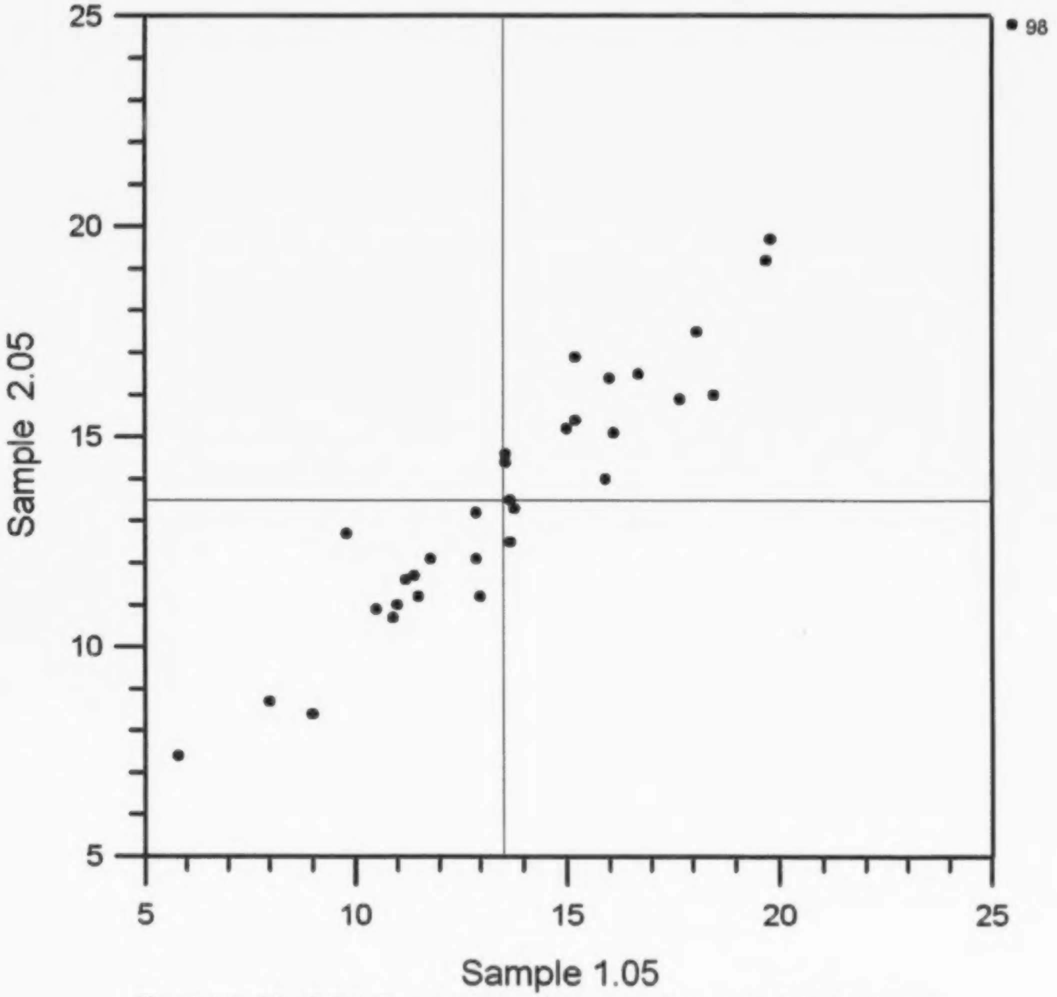


Test 10: Absorption (Coarse Aggregate)

	Mat 1	Mat 2
Mean	1.544	1.549
Median	1.590	1.590
Std Dev	0.143	0.167
n = 93		

Labs Eliminated: 20, 68, 120, 144

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

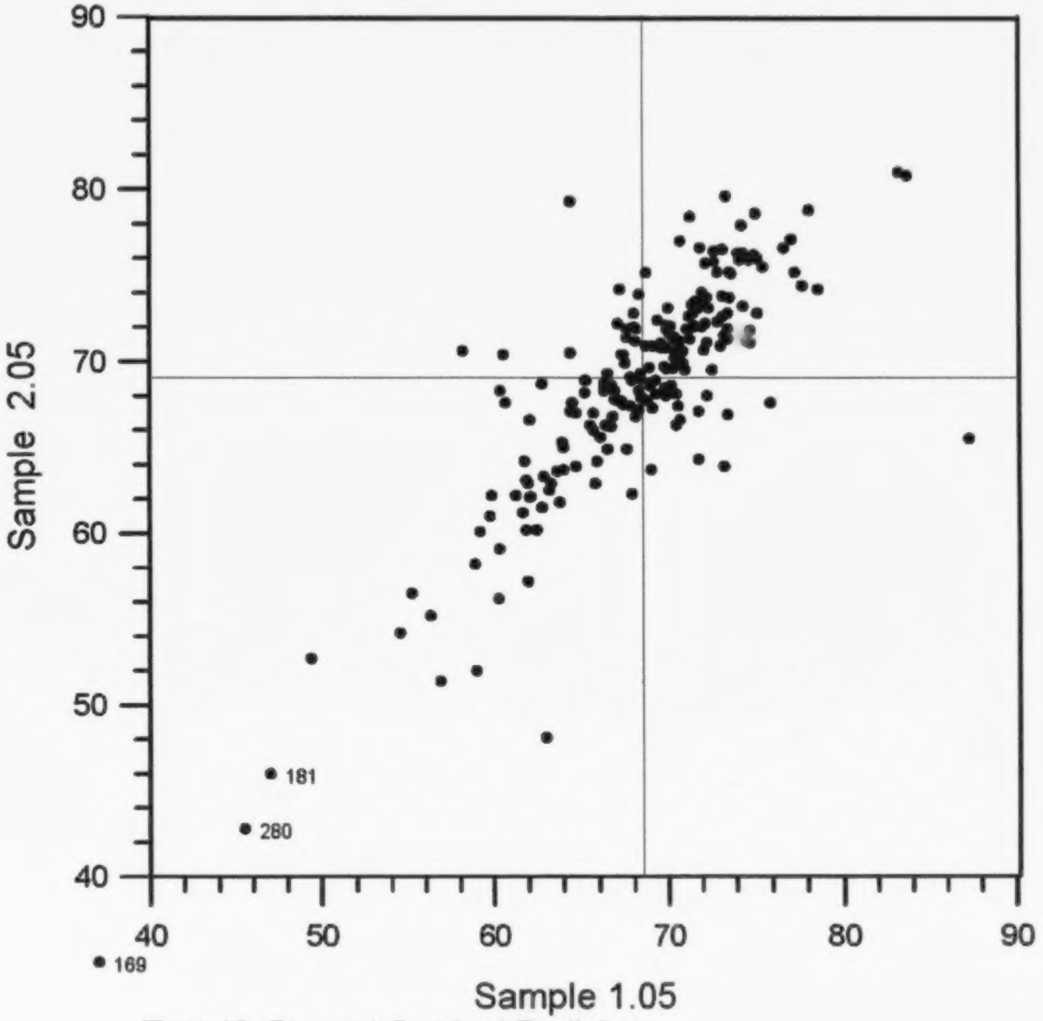


Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.613	13.516
Median	12.800	13.550
Std Dev	3.375	2.997
n = 31		

Lab Eliminated: 98

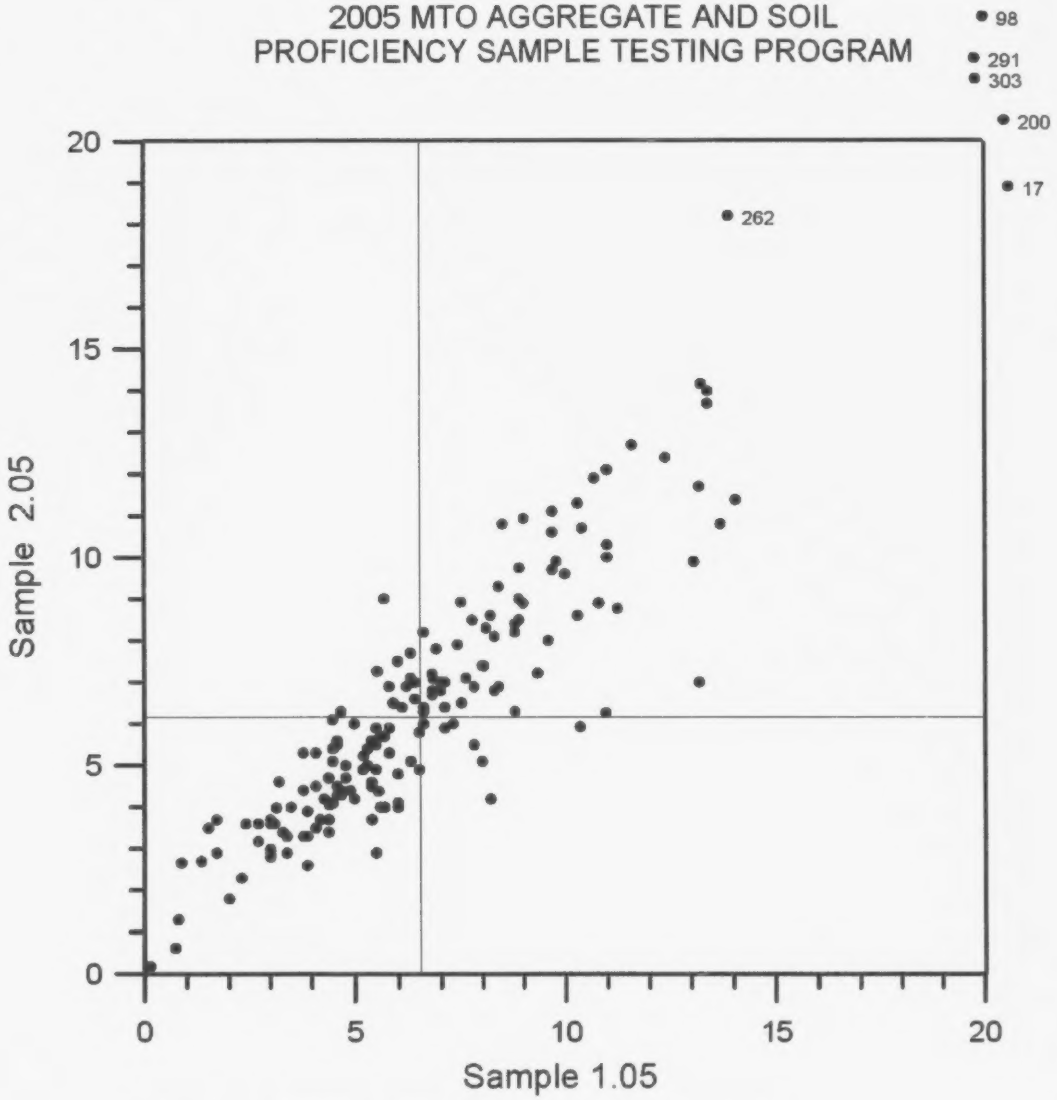
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.750	69.097
Median	68.350	64.550
Std Dev	5.268	5.591
n = 201		

Labs Eliminated: 169, 181, 280



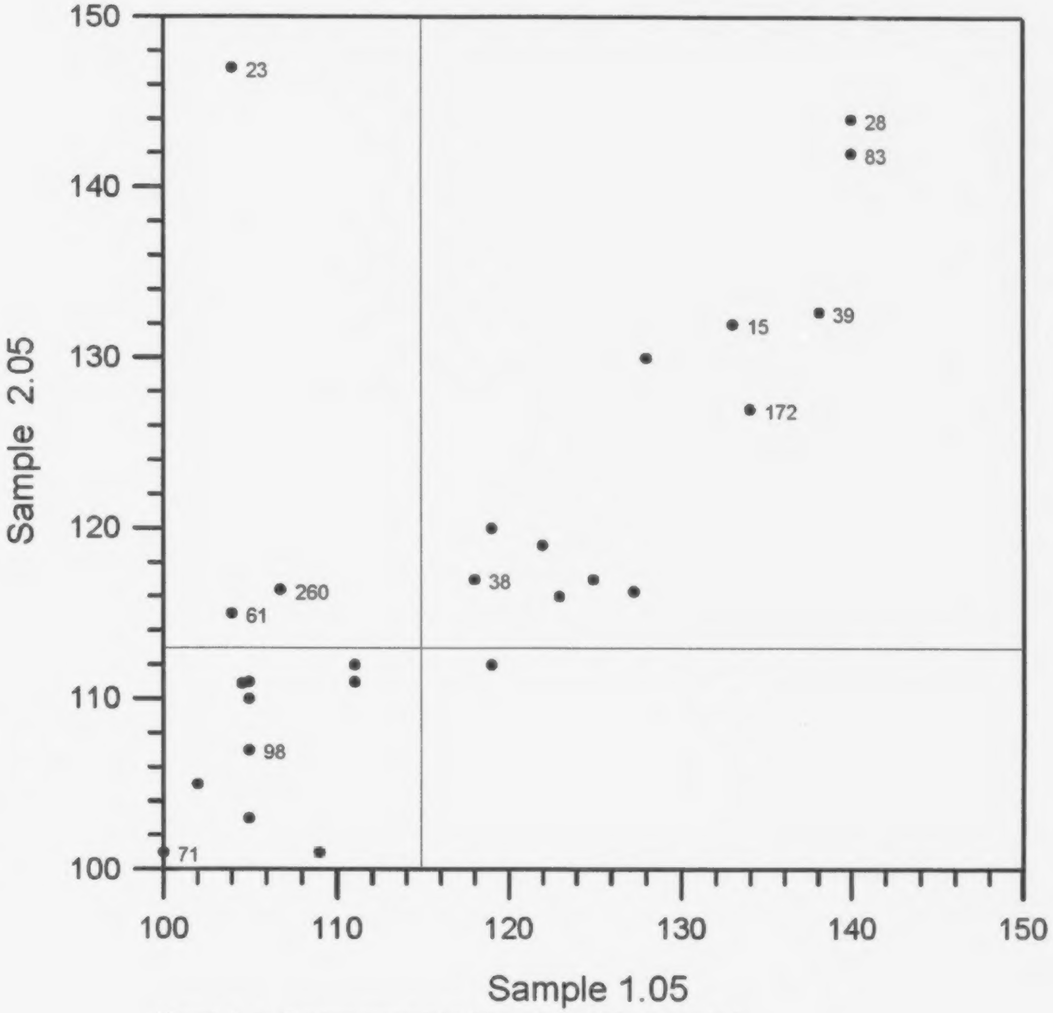
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	6.488	6.253
Median	7.095	7.170
Std Dev	3.021	2.763
n = 162		

Labs Eliminated: 17, 98, 200, 262, 291, 303

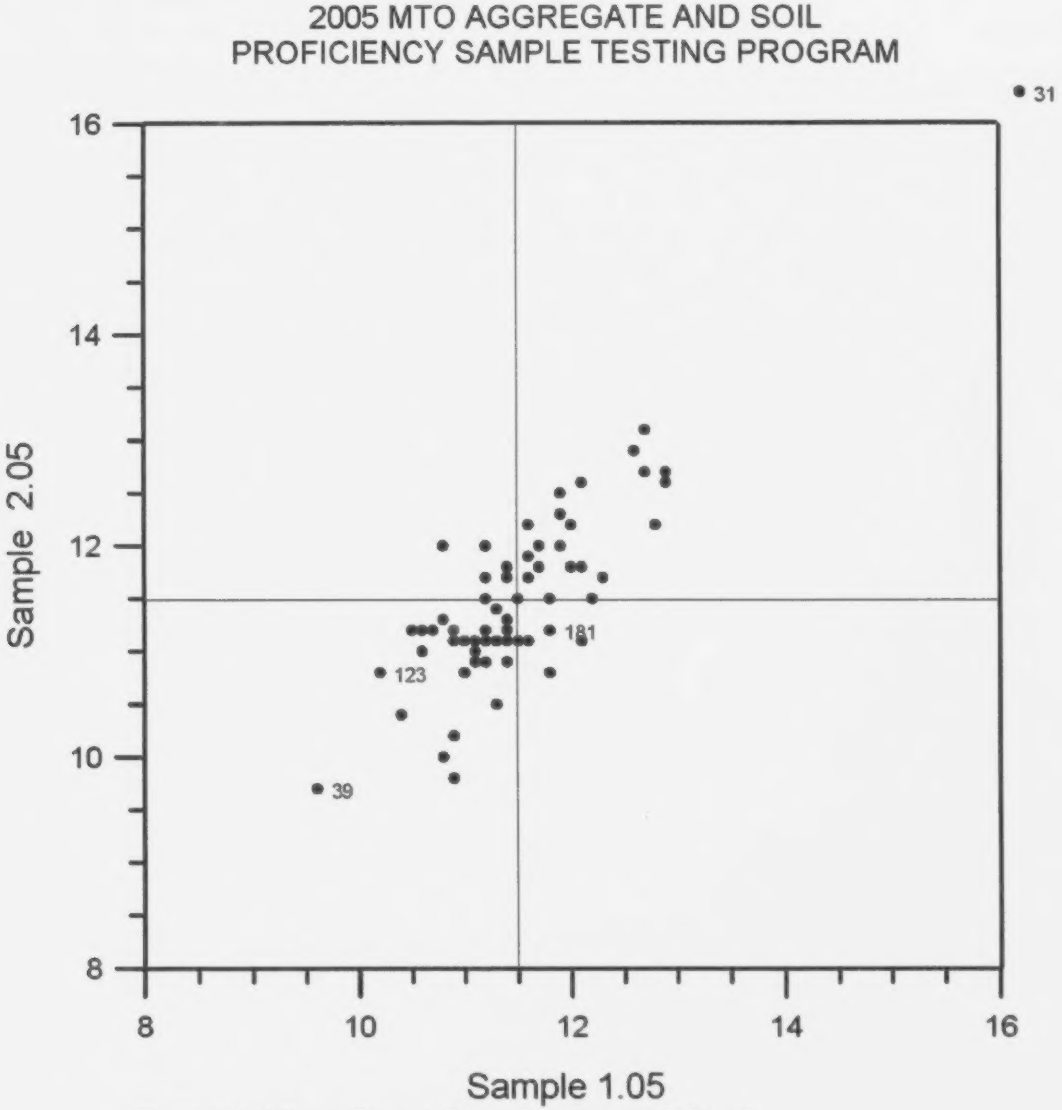
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	114.393	112.947
Median	115.000	115.500
Std Dev	--	--
n = 15		

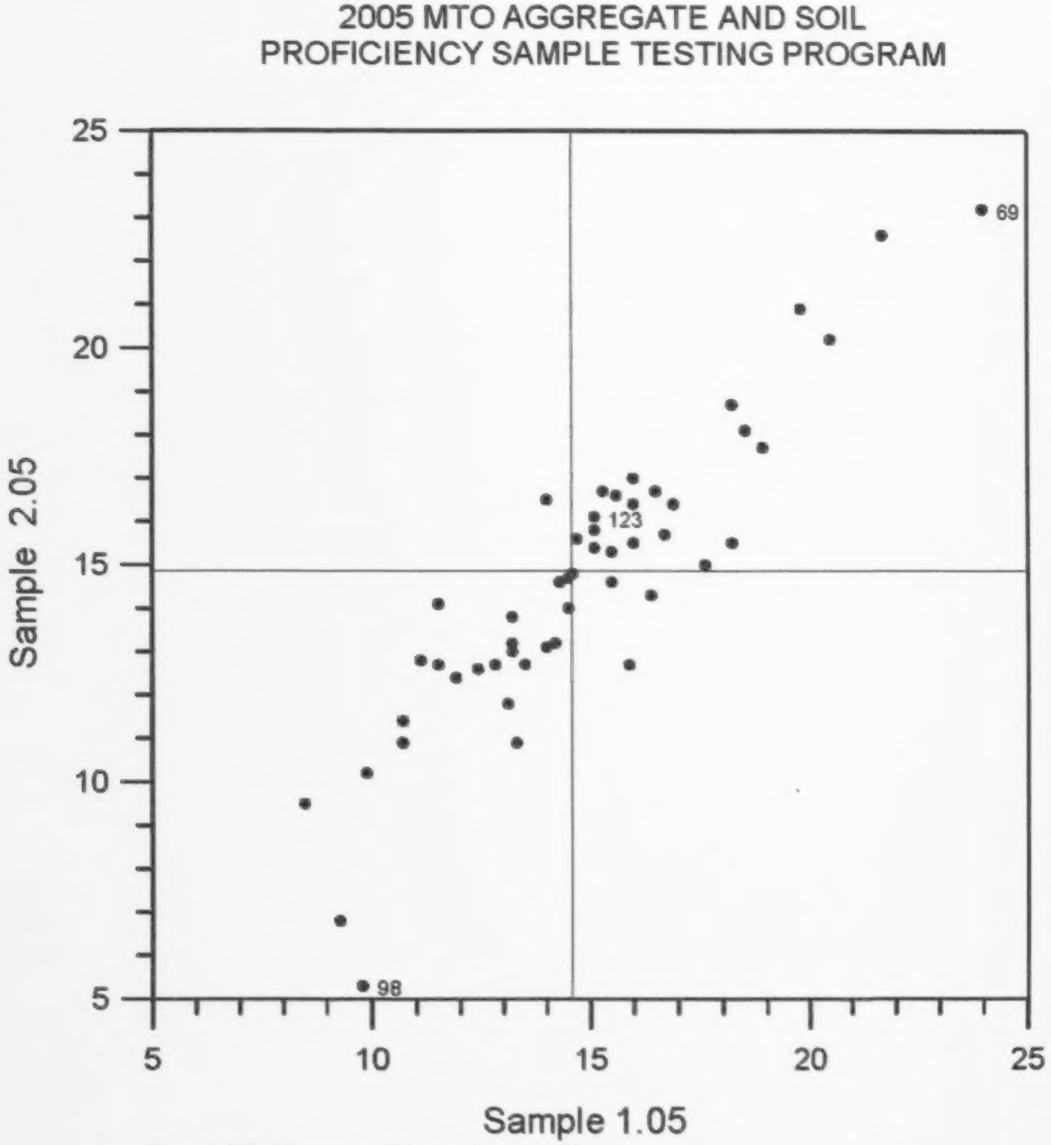
Lab Eliminated: 15, 23, 28, 38, 39, 61, 71, 83, 98, 172, 260



Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	11.492	11.435
Median	11.650	11.450
Std Dev	0.613	0.723
n = 61		

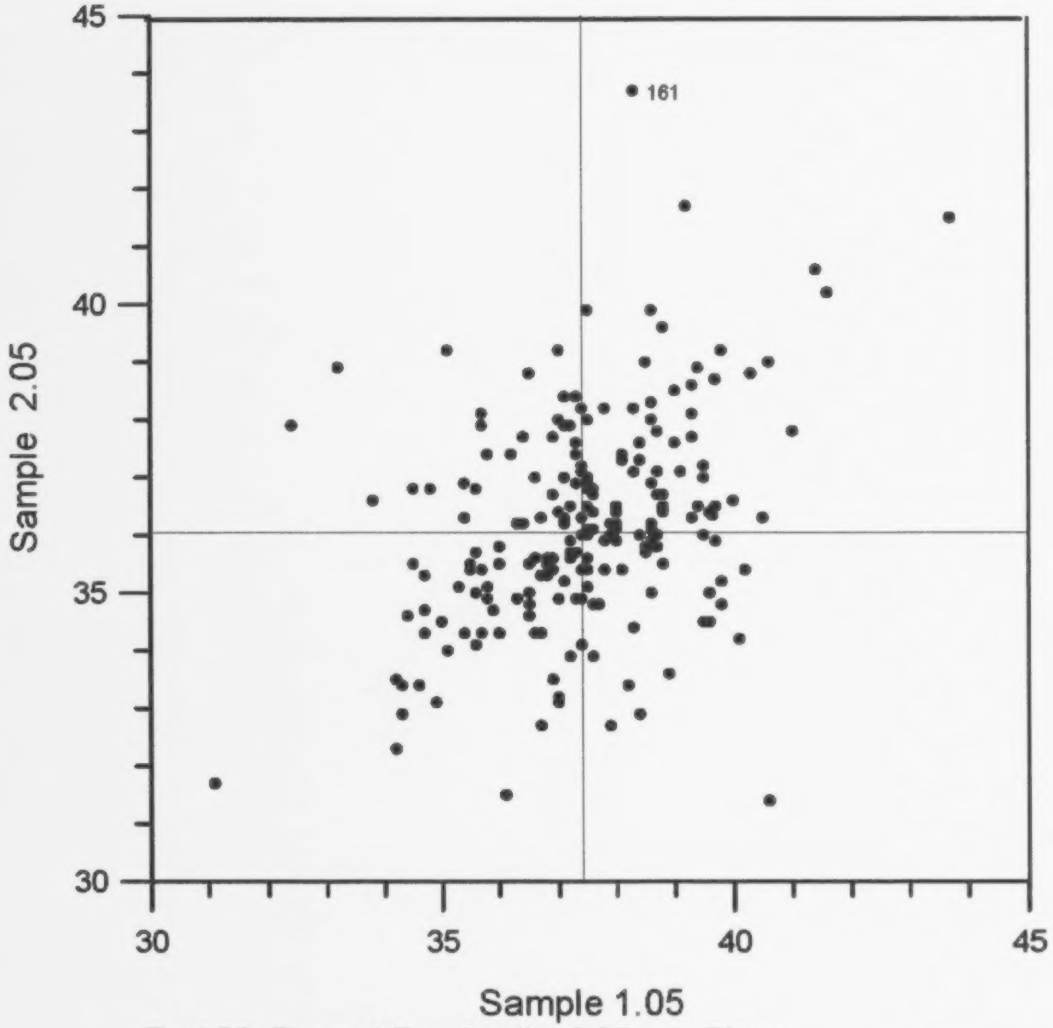
Labs eliminated: 31, 39, 123, 181



Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	14.590	14.771
Median	15.100	14.700
Std Dev	2.947	3.162
n = 47		

Lab eliminated: 69, 98, 123



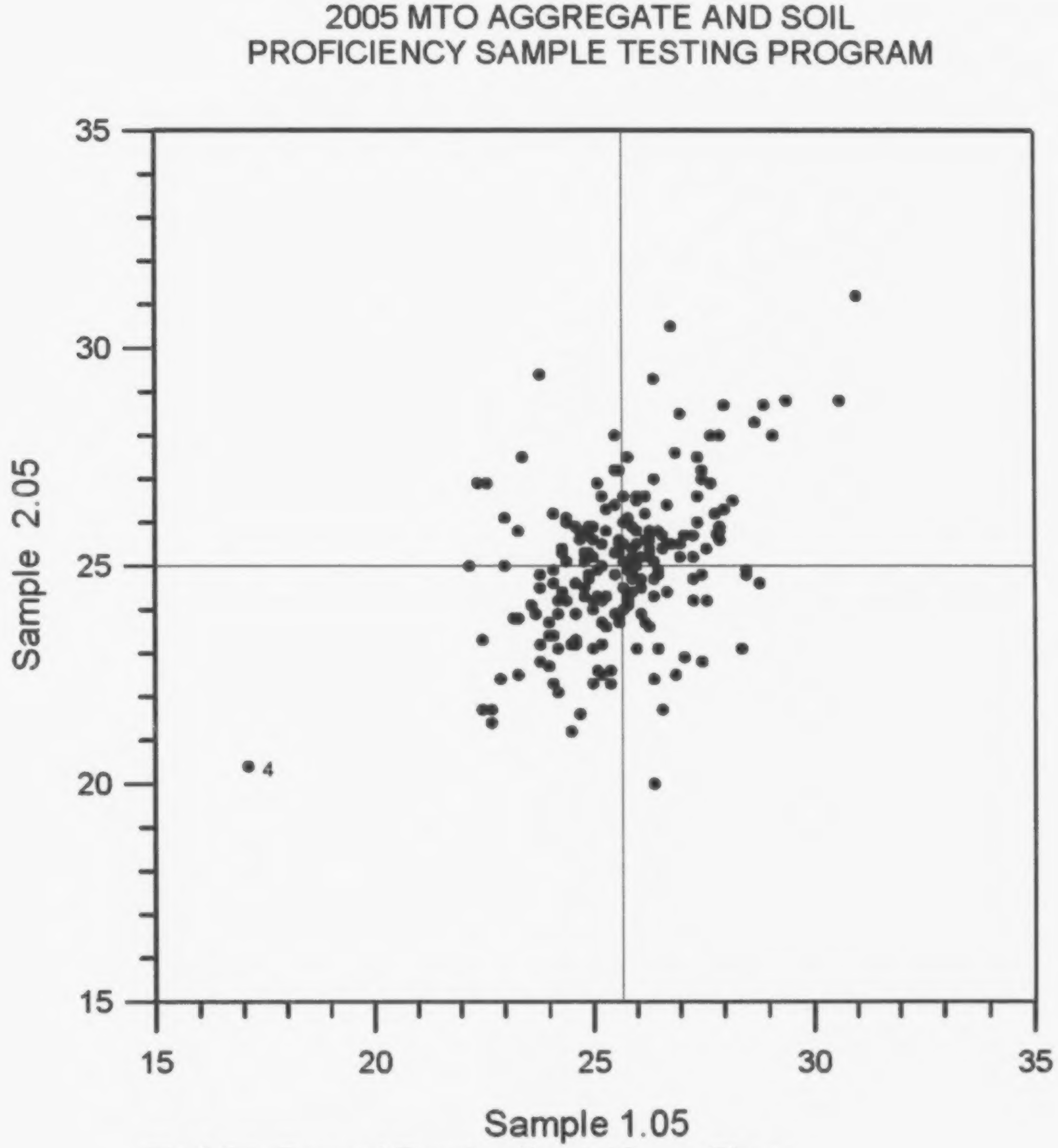
2005 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	37.446	36.164
Median	37.400	36.550
Std Dev	1.727	1.785

n = 205

Labs Eliminated: 161



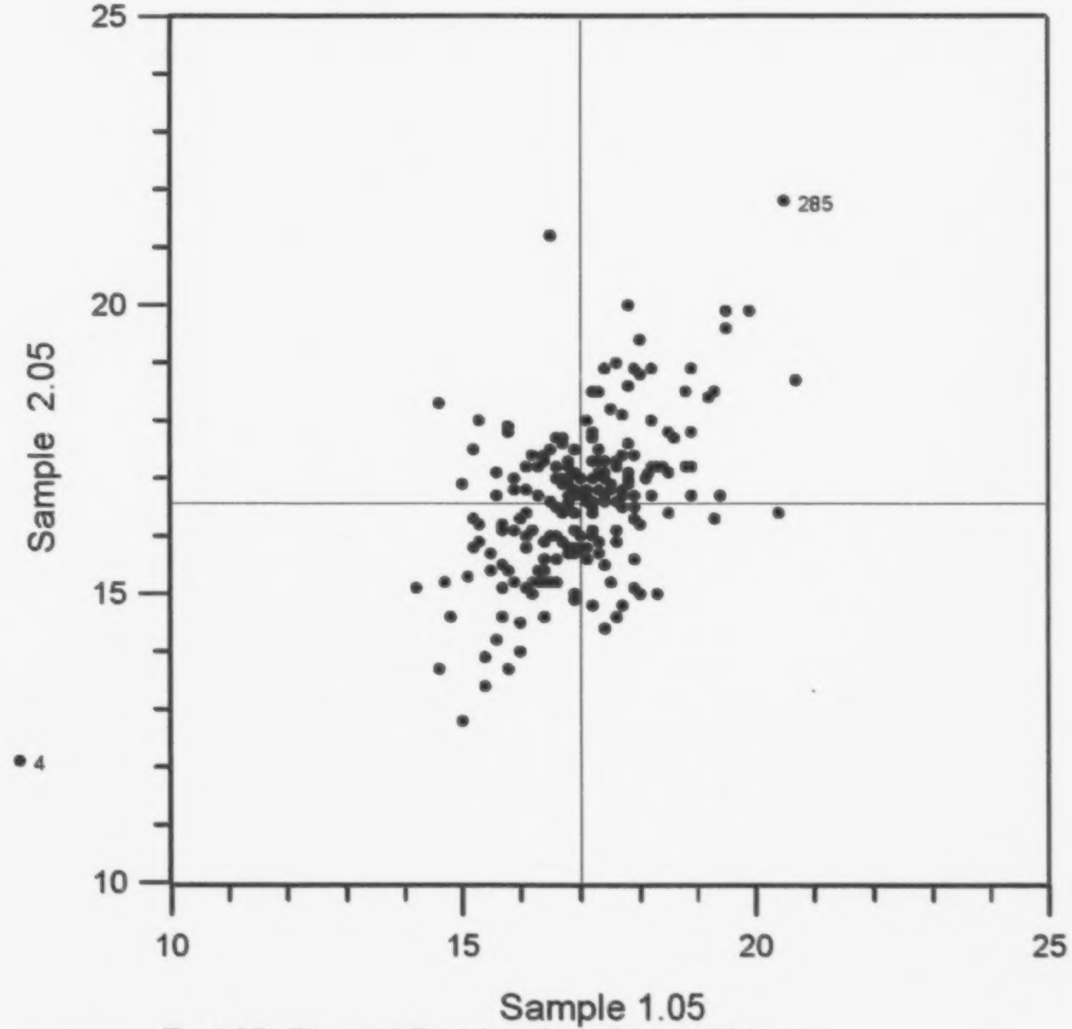
Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	25.692	25.011
Median	26.600	25.600
Std Dev	1.524	1.755

n = 205

Labs Eliminated: 4

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

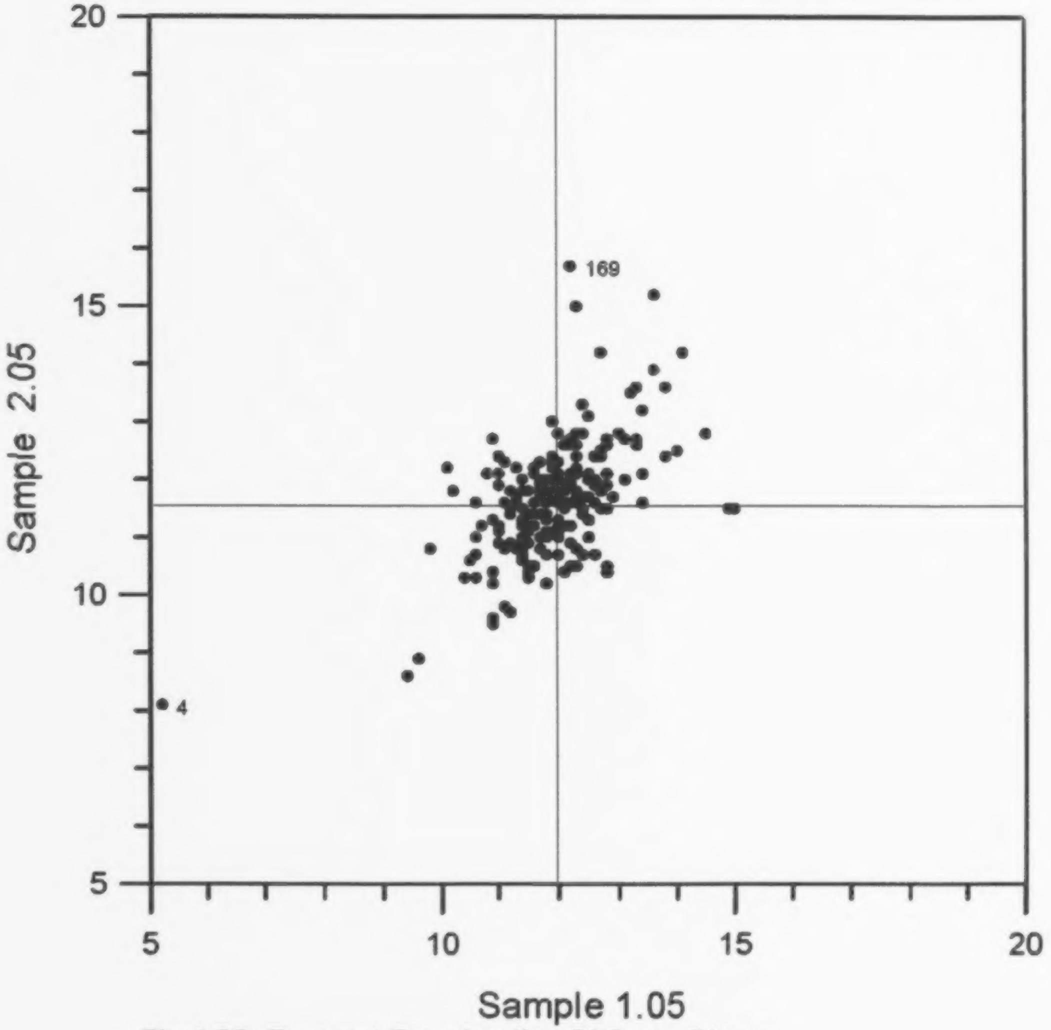


Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	17.021	16.585
Median	17.450	17.000
Std Dev	1.131	1.321
n = 204		

Lab Eliminated: 4, 285

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



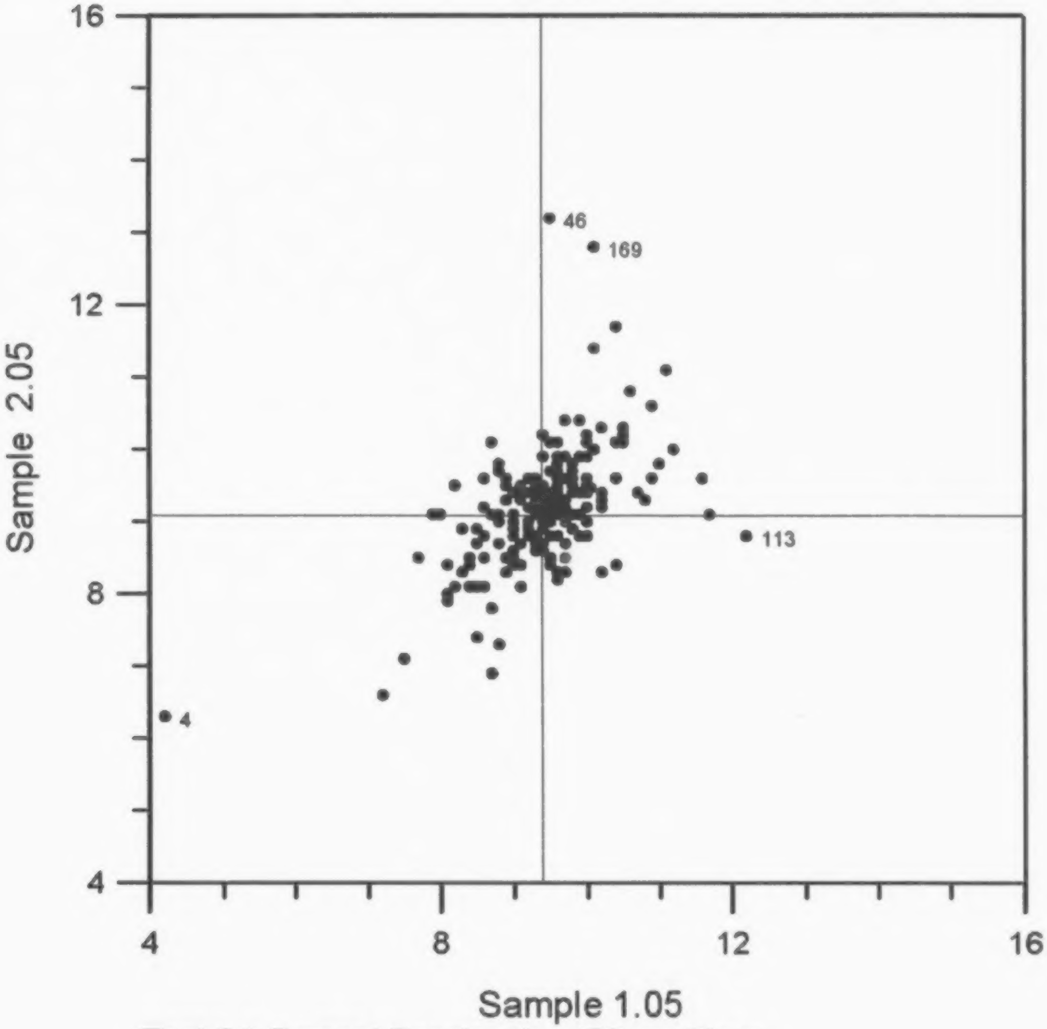
Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	11.959	11.630
Median	12.000	11.900
Std Dev	0.849	0.958

n = 204

Labs Eliminated: 4, 169

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

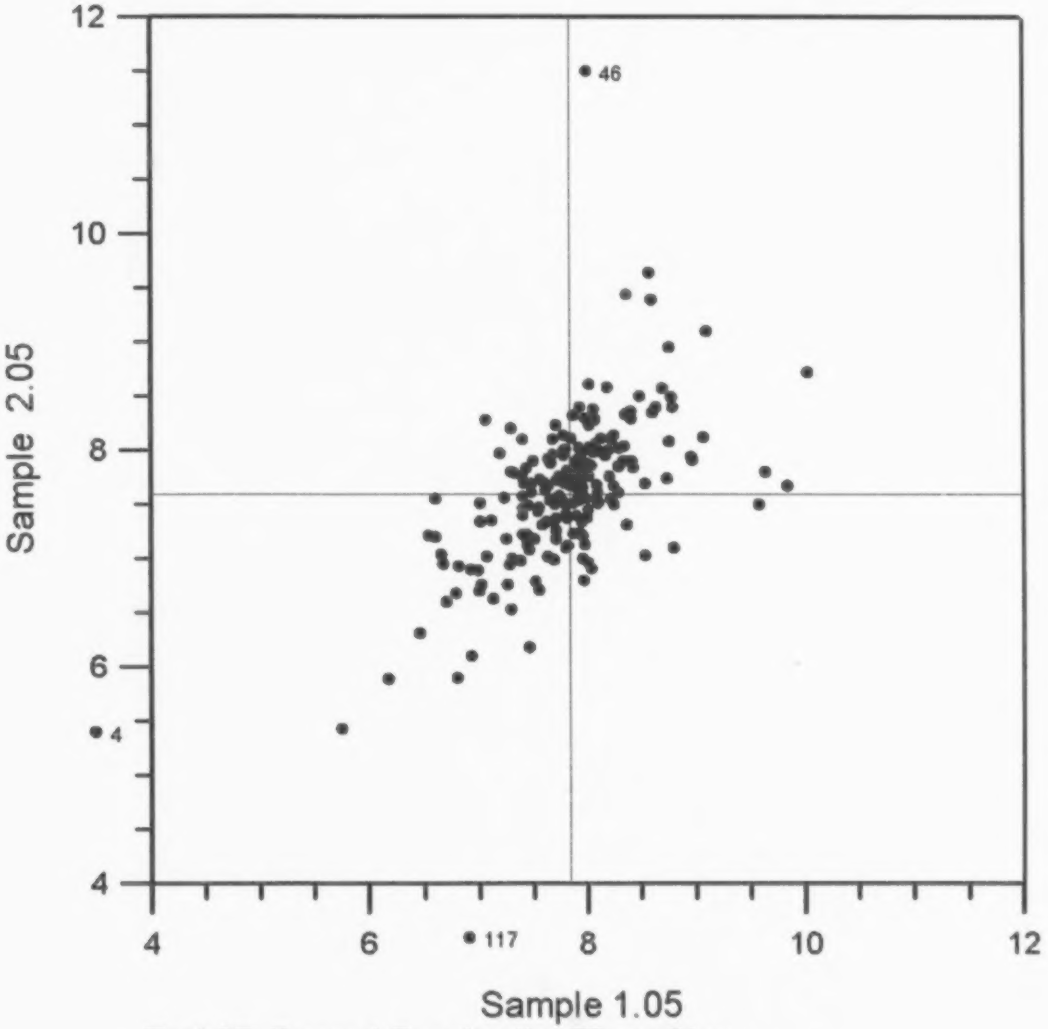


Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	9.428	9.181
Median	9.450	9.150
Std Dev	0.684	0.701
n = 202		

Lab Eliminated: 4, 46, 113, 169

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

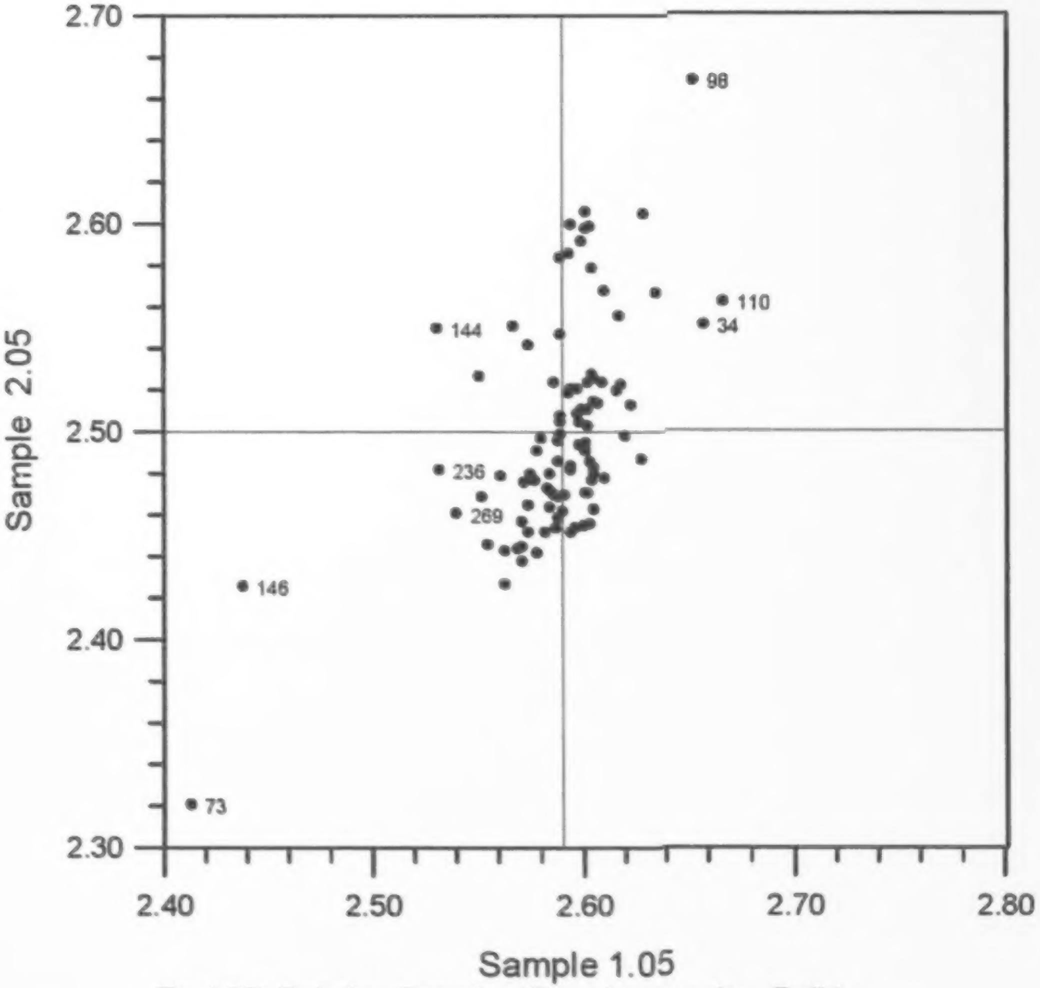


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.836	7.626
Median	7.895	7.535
Std Dev	0.604	0.614
n = 203		

Labs Eliminated: 4, 46, 117

2005 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

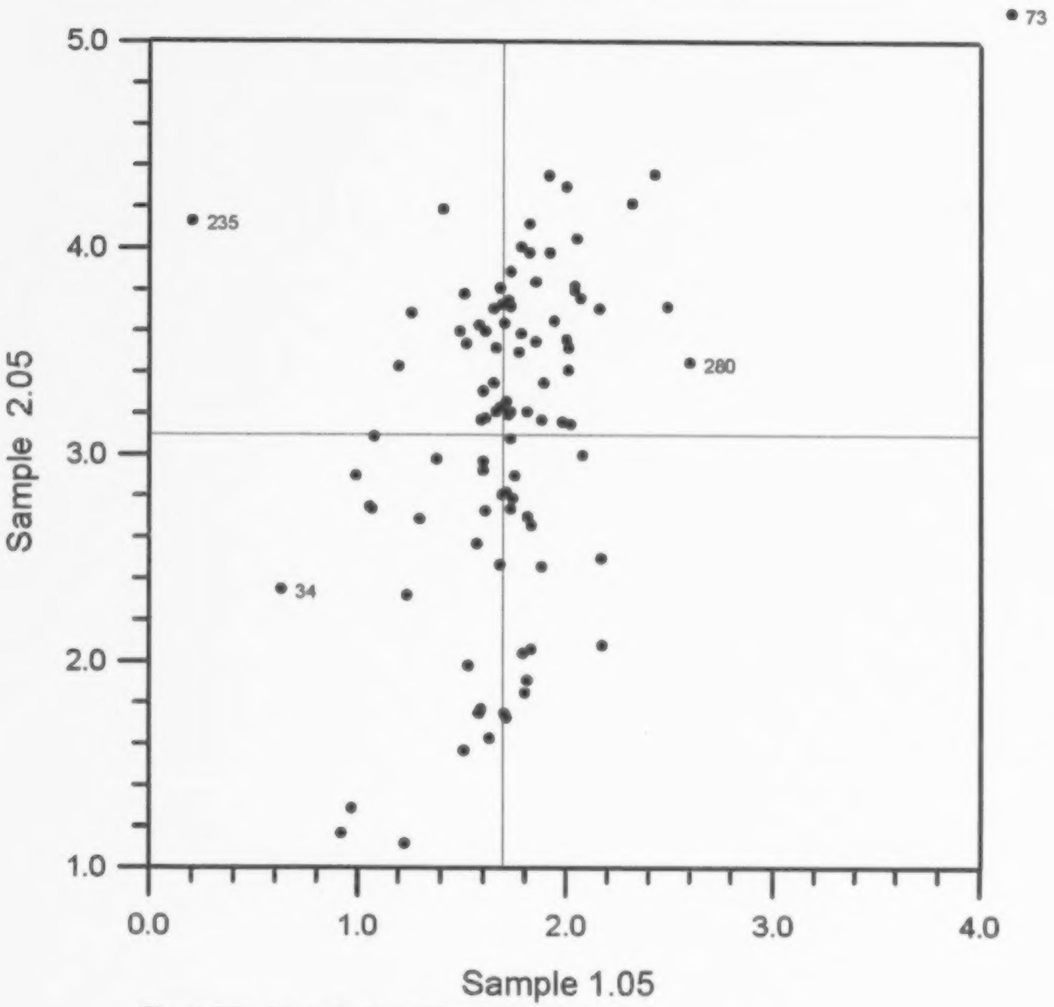


Test 27: Relative Density, (Fine Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.593	2.501
Median	2.593	2.517
Std Dev	0.017	0.045
n = 87		

Labs Eliminated: 34, 73, 98, 110, 144, 146, 236, 269

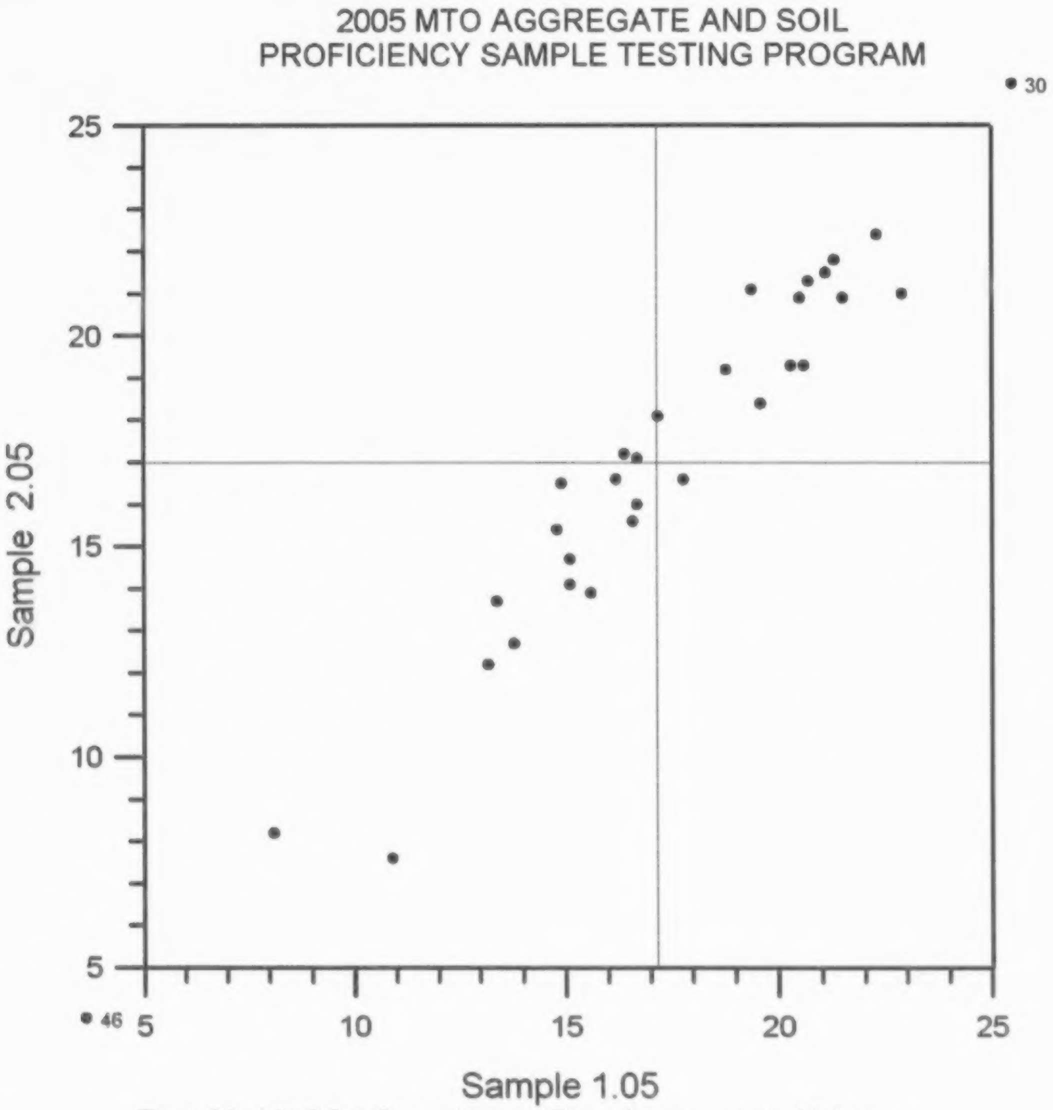
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 28: Absorption (Fine Aggregate)

	Mat 1	Mat 2
Mean	1.713	3.109
Median	1.705	2.740
Std Dev	0.304	0.781
n = 91		

Labs Eliminated: 34, 73, 235, 280

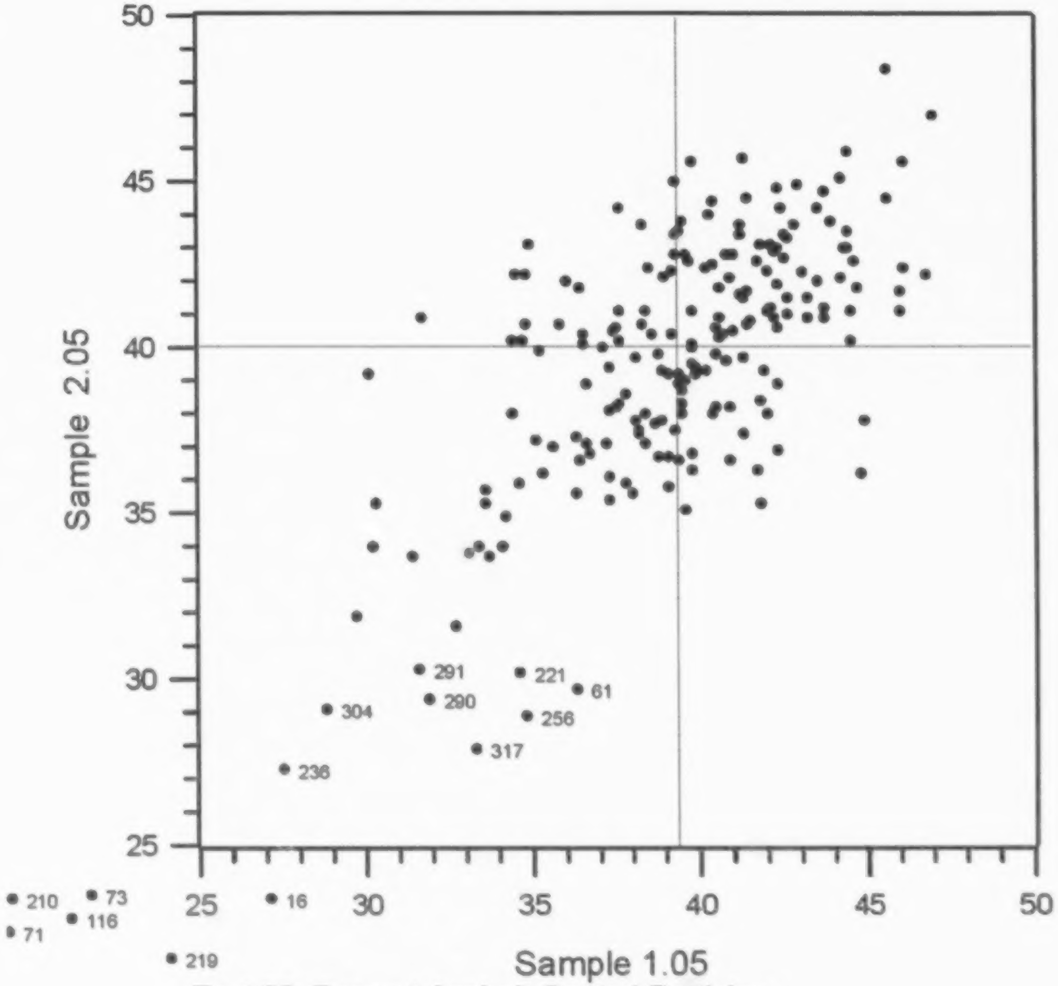


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.293	17.010
Median	15.500	15.000
Std Dev	3.566	3.875
n = 29		

Lab Eliminated: 30, 46

2005 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

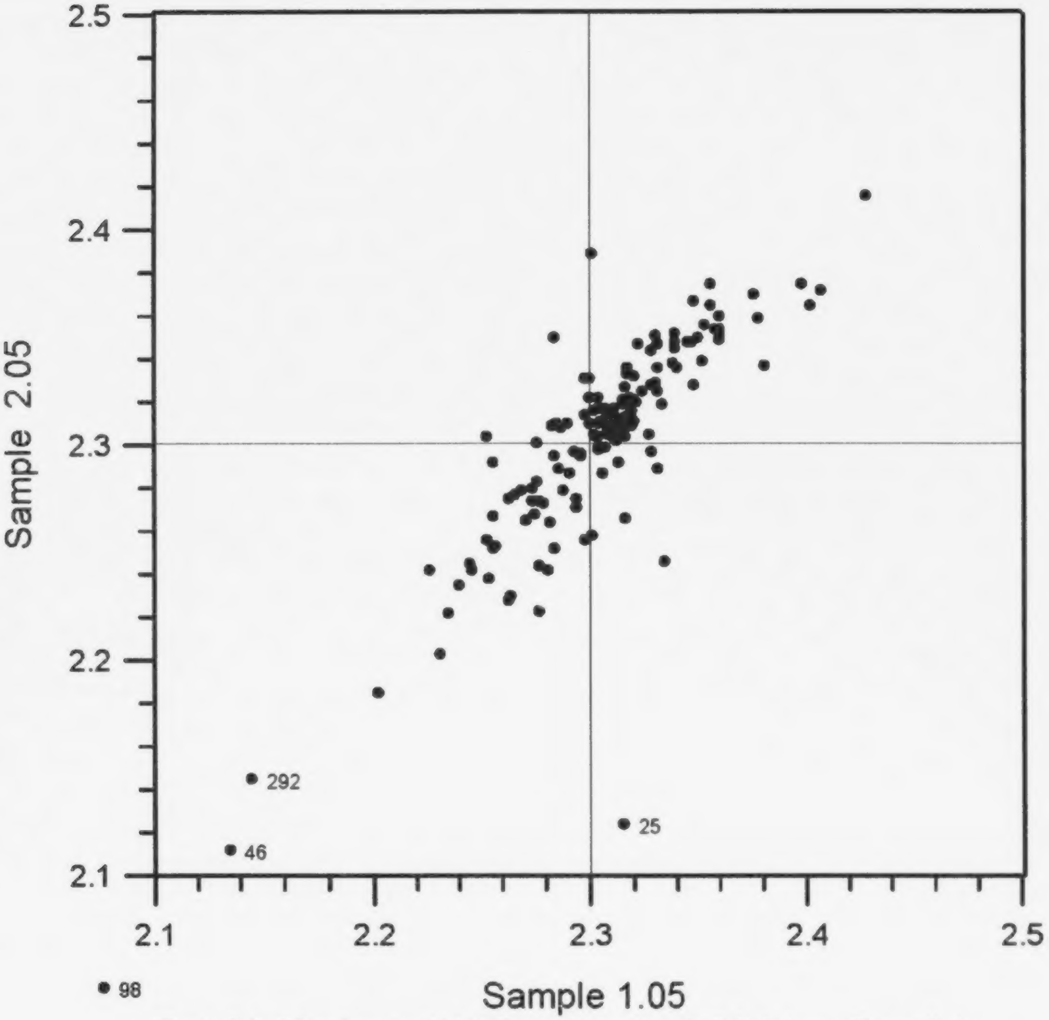


Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	39.427	40.088
Median	38.350	40.000
Std Dev	3.611	3.116
n = 188		

Labs Eliminated: 16, 61, 71, 73, 116, 210, 219, 221, 236, 256
290, 291, 304, 317

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

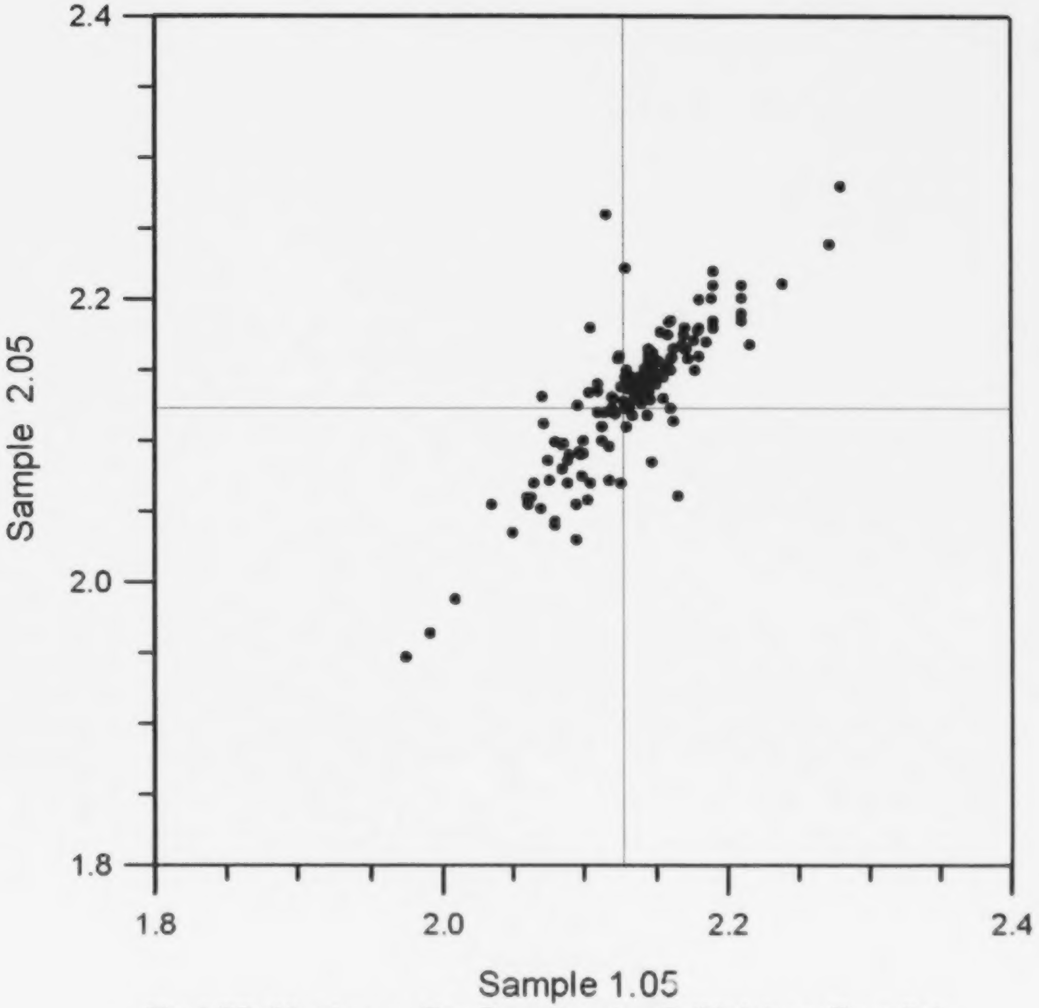


Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.308	2.306
Median	2.315	2.301
Std Dev	0.037	0.040
n = 143		

Labs Eliminated: 25, 46, 98, 292

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



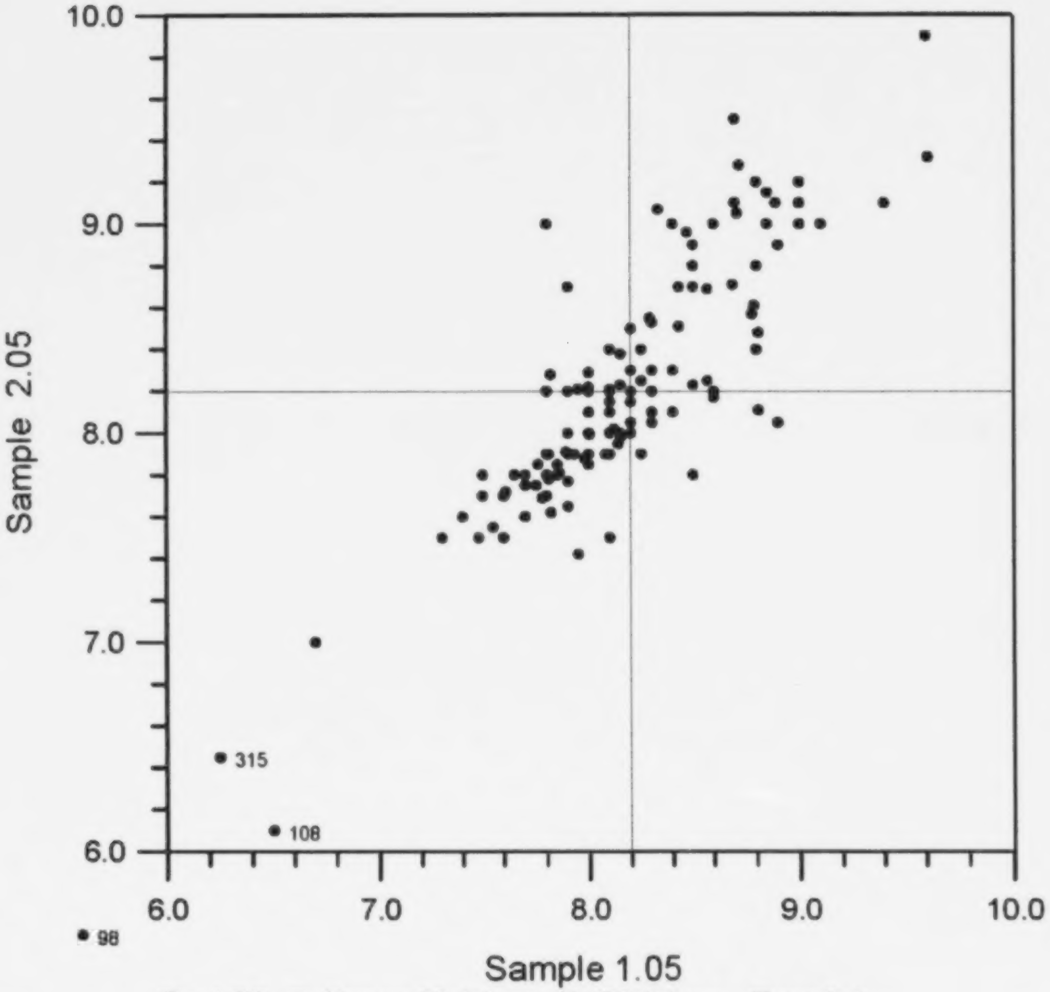
Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.134	2.133
Median	2.127	2.114
Std Dev	0.045	0.051

n = 147

Labs Eliminated: None

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

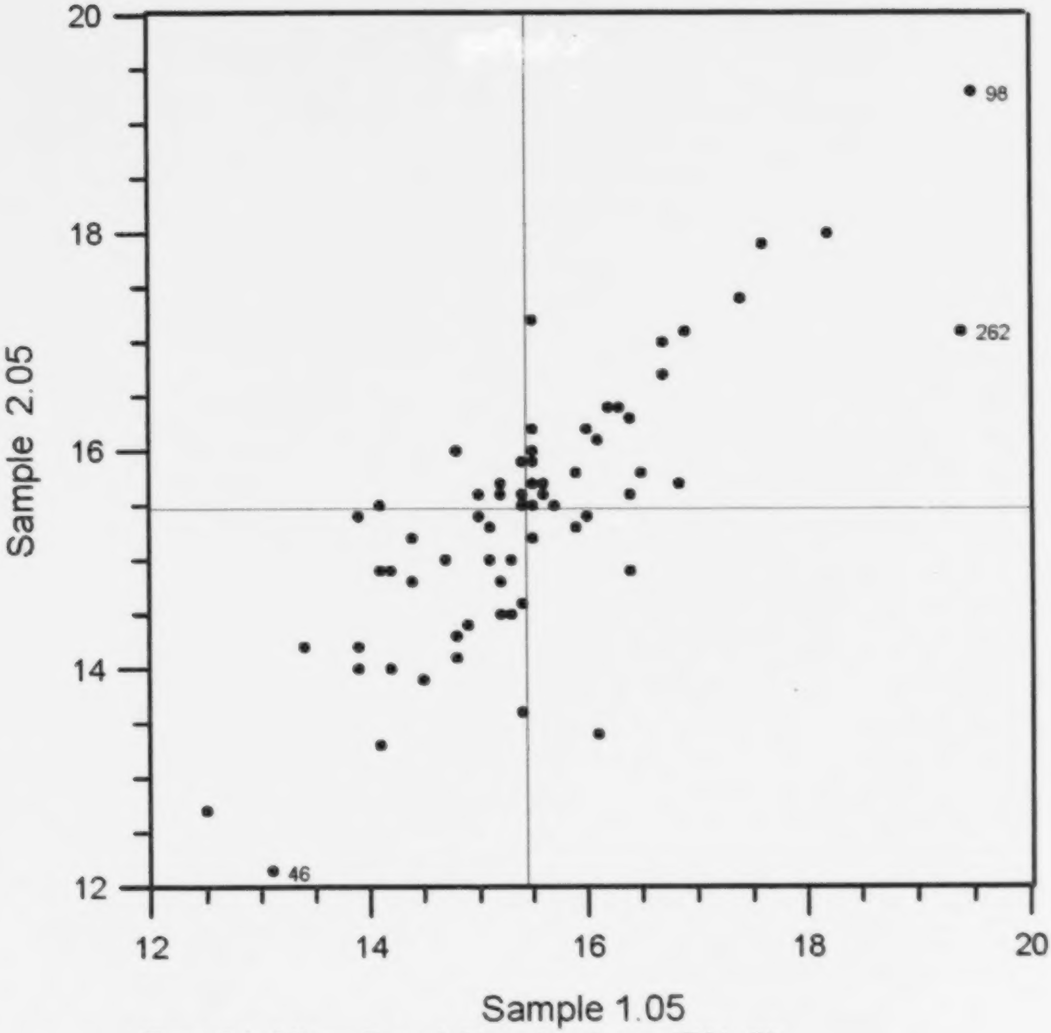


Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	8.160	8.198
Median	8.155	8.450
Std Dev	0.471	0.519
n = 144		

Labs Eliminated: 98, 108, 315

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

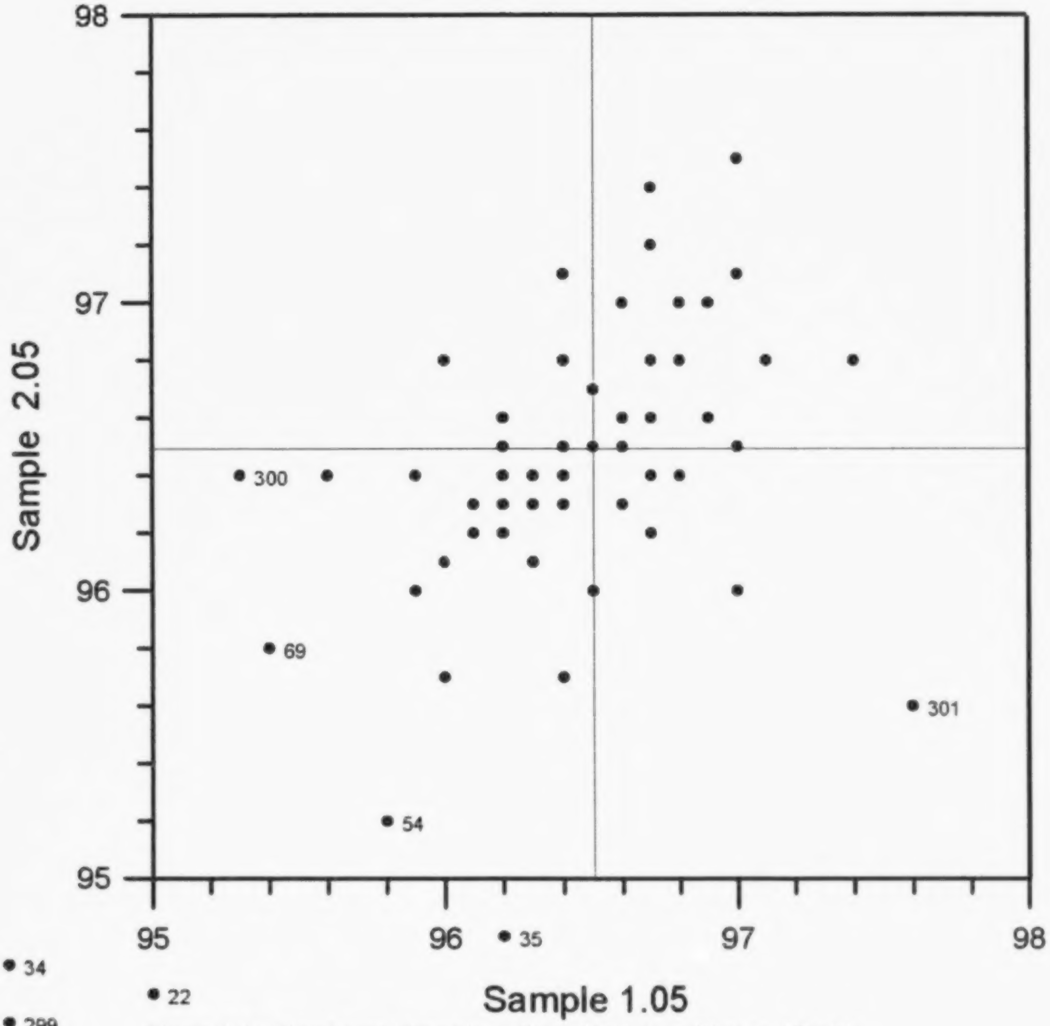


Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	15.353	15.403
Median	15.350	15.350
Std Dev	1.063	1.087
n = 62		

Lab eliminated: 46, 98, 262

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

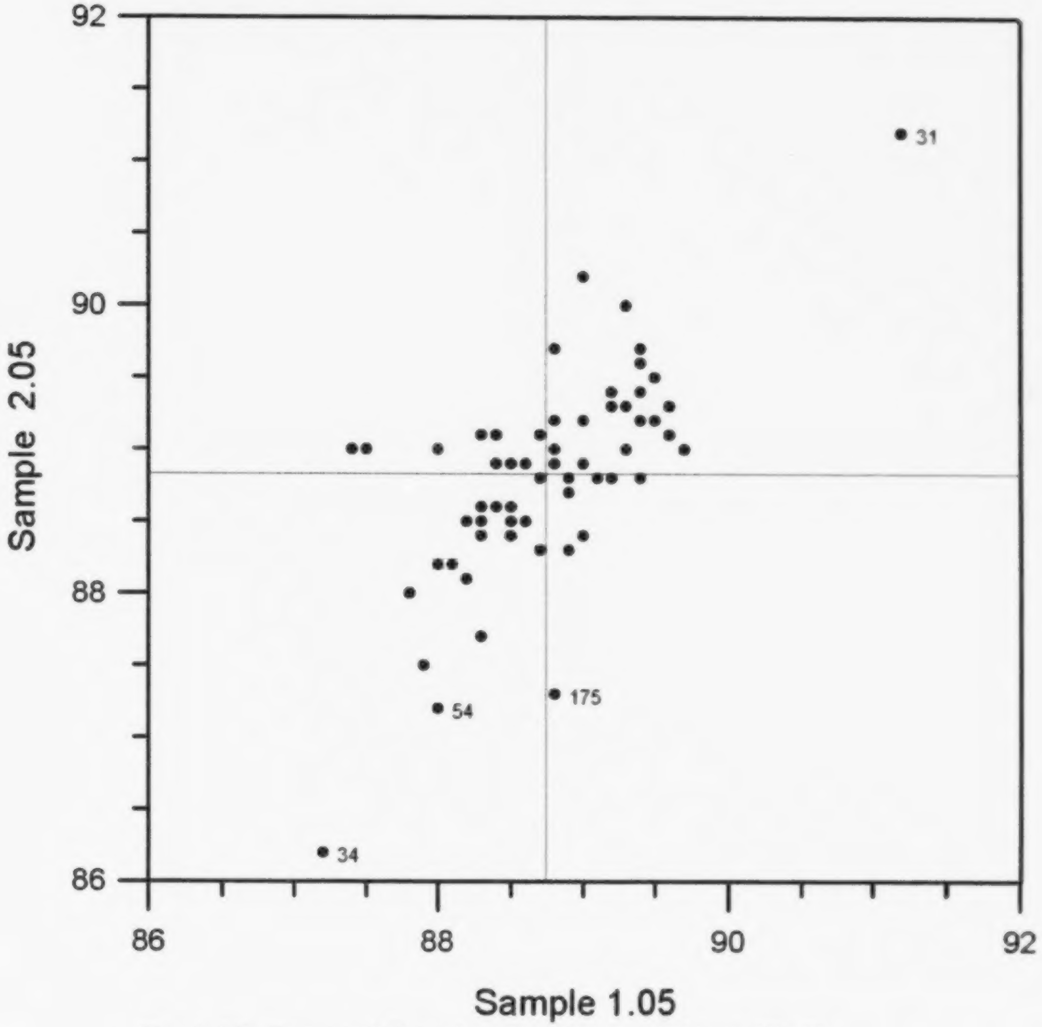


Test 41: Percent Passing the 425 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	96.474	96.479
Median	96.500	96.600
Std Dev	0.351	0.383
n = 59		

Labs eliminated: 22, 34, 35, 54, 69, 299, 300, 301

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

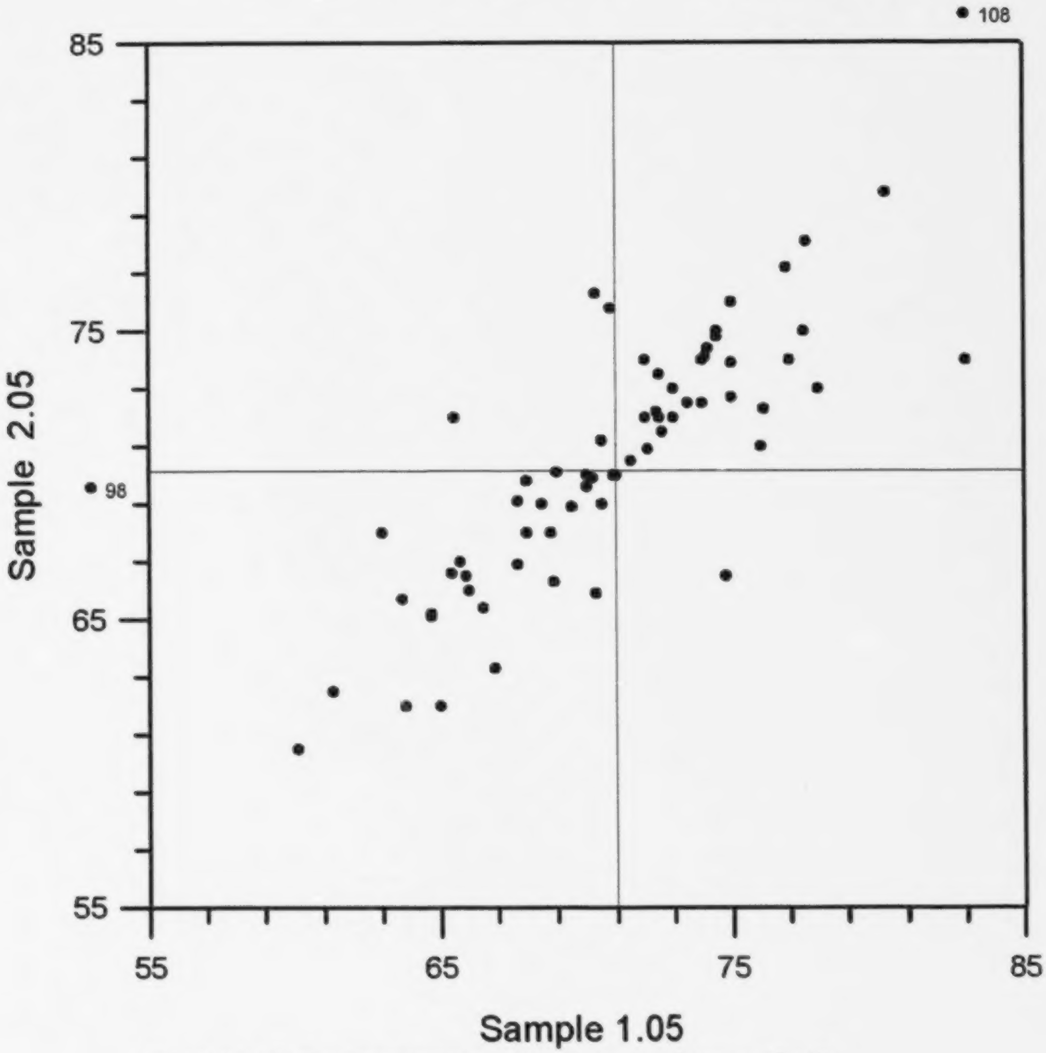


Test 42: Percent Passing the 75 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	88.720	88.852
Median	88.550	88.850
Std Dev	0.567	0.525
n = 63		

Labs eliminated: 31, 34, 54, 175

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



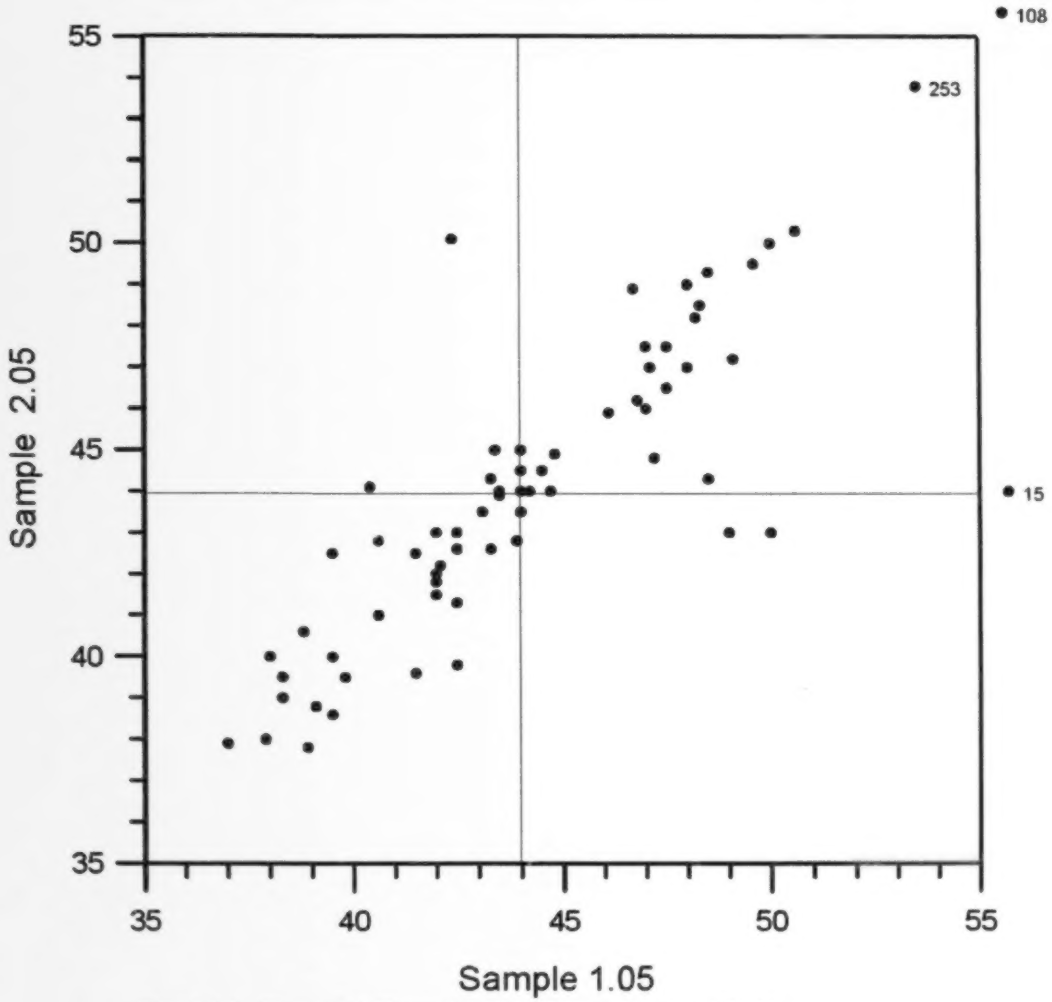
Test 43: Percent Passing the 20 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	71.021	70.353
Median	71.550	70.150
Std Dev	4.841	4.130

n = 65

Labs eliminated: 98, 108

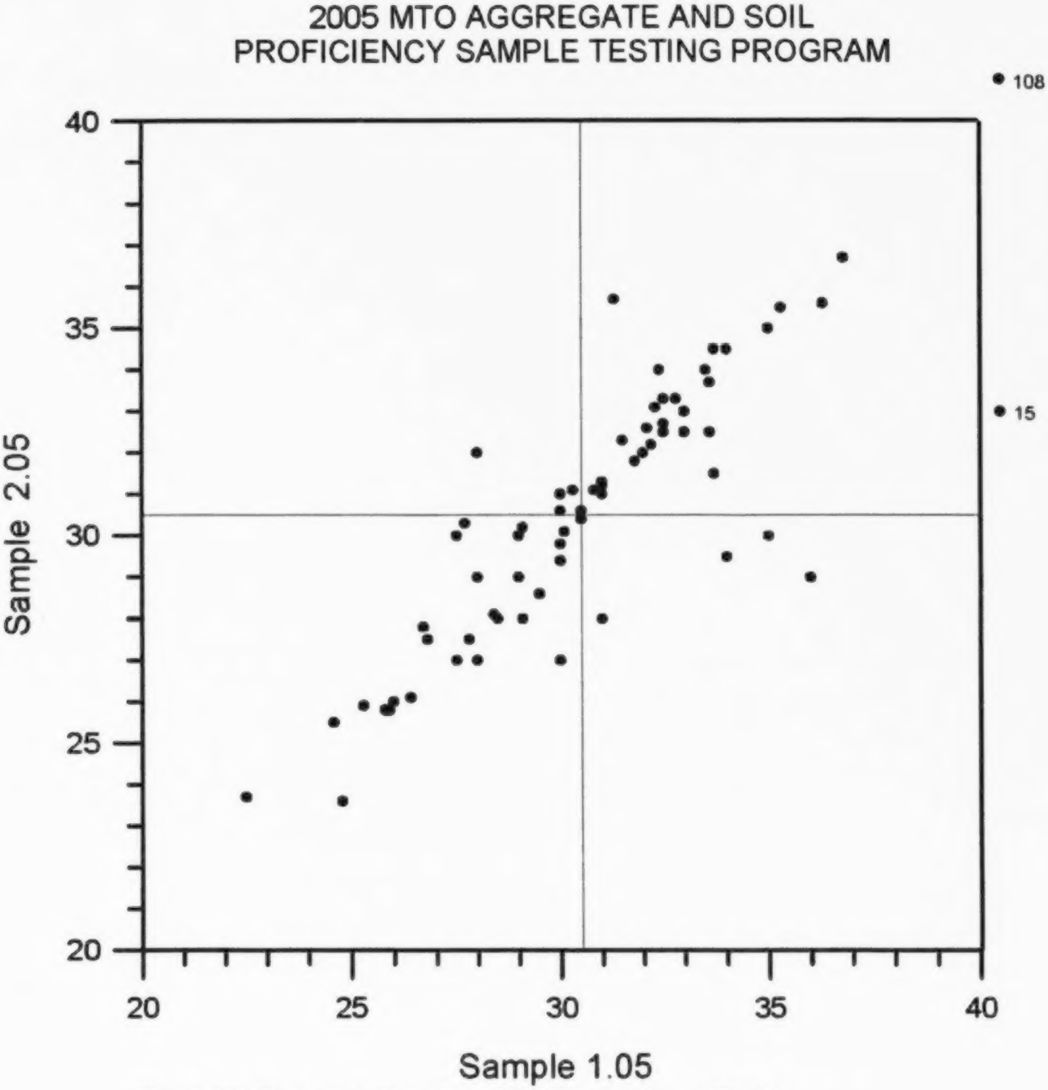
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	43.971	43.809
Median	43.800	44.050
Std Dev	3.761	3.297
n = 64		

Labs eliminated: 15, 108, 253

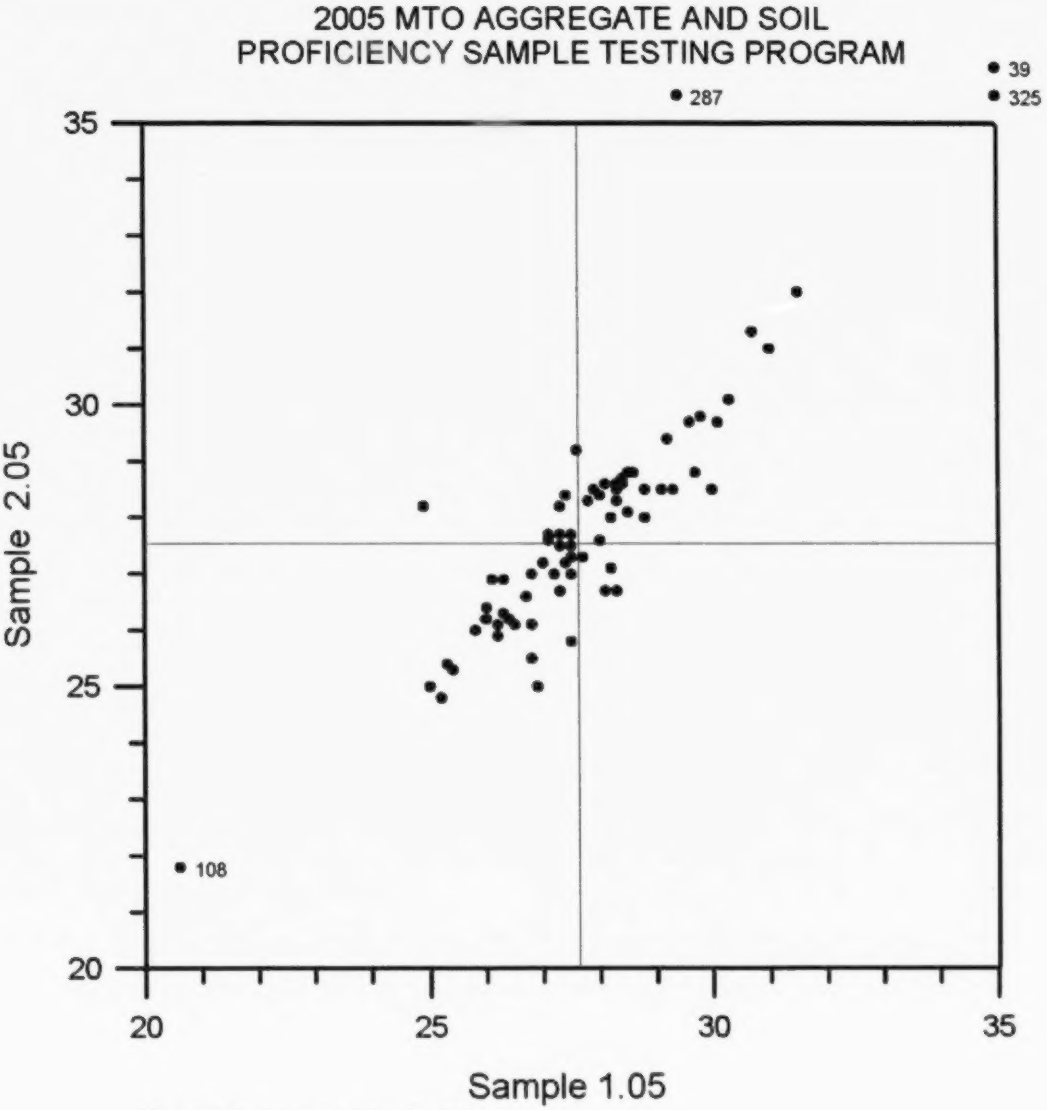


Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	30.469	30.470
Median	29.650	30.150
Std Dev	3.130	3.038

n = 65

LabsEliminated: 15, 108

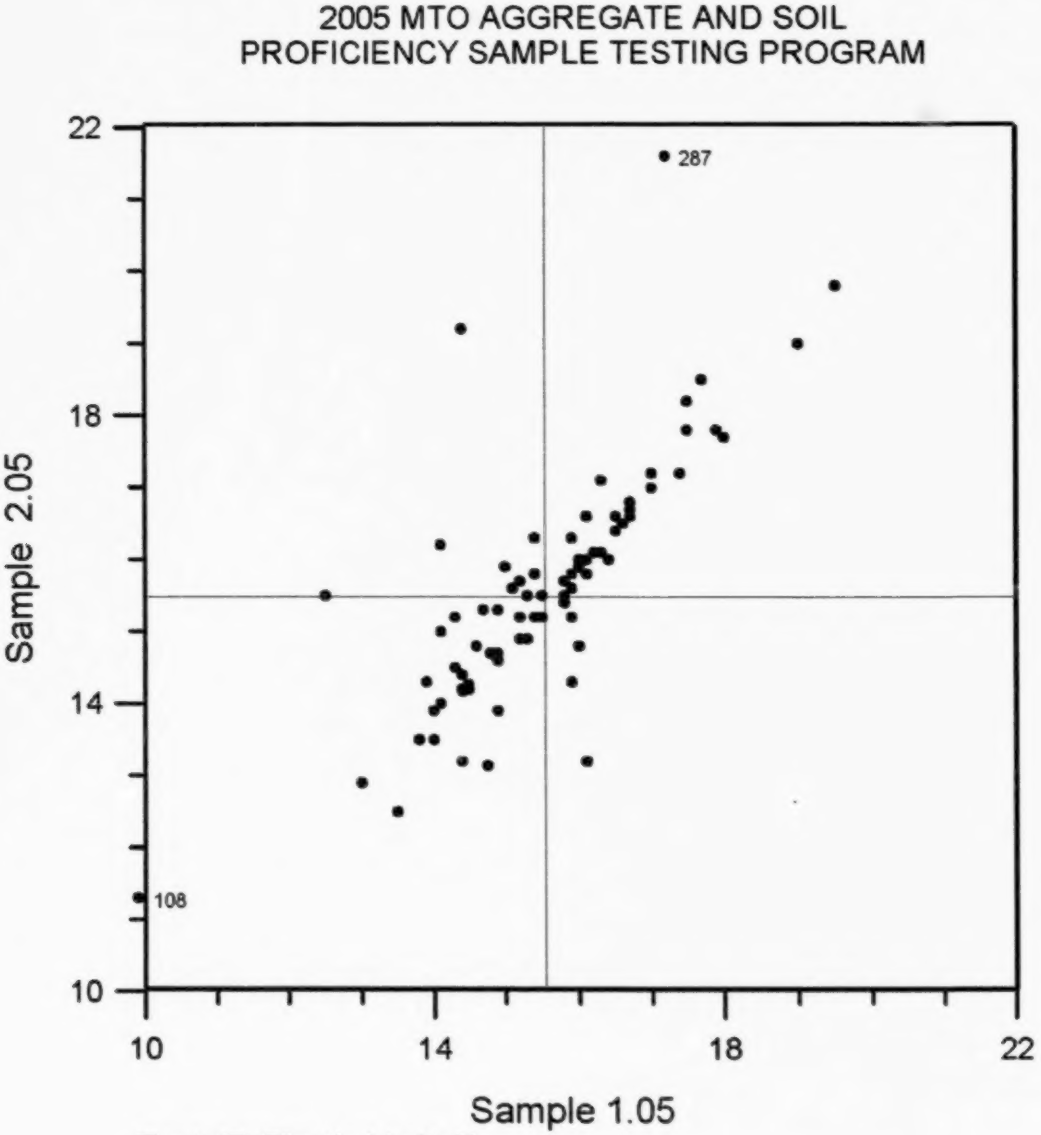


Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	27.721	27.656
Median	28.200	28.400
Std Dev	1.425	1.469

n = 73

Labs eliminated: 39, 108, 287, 325



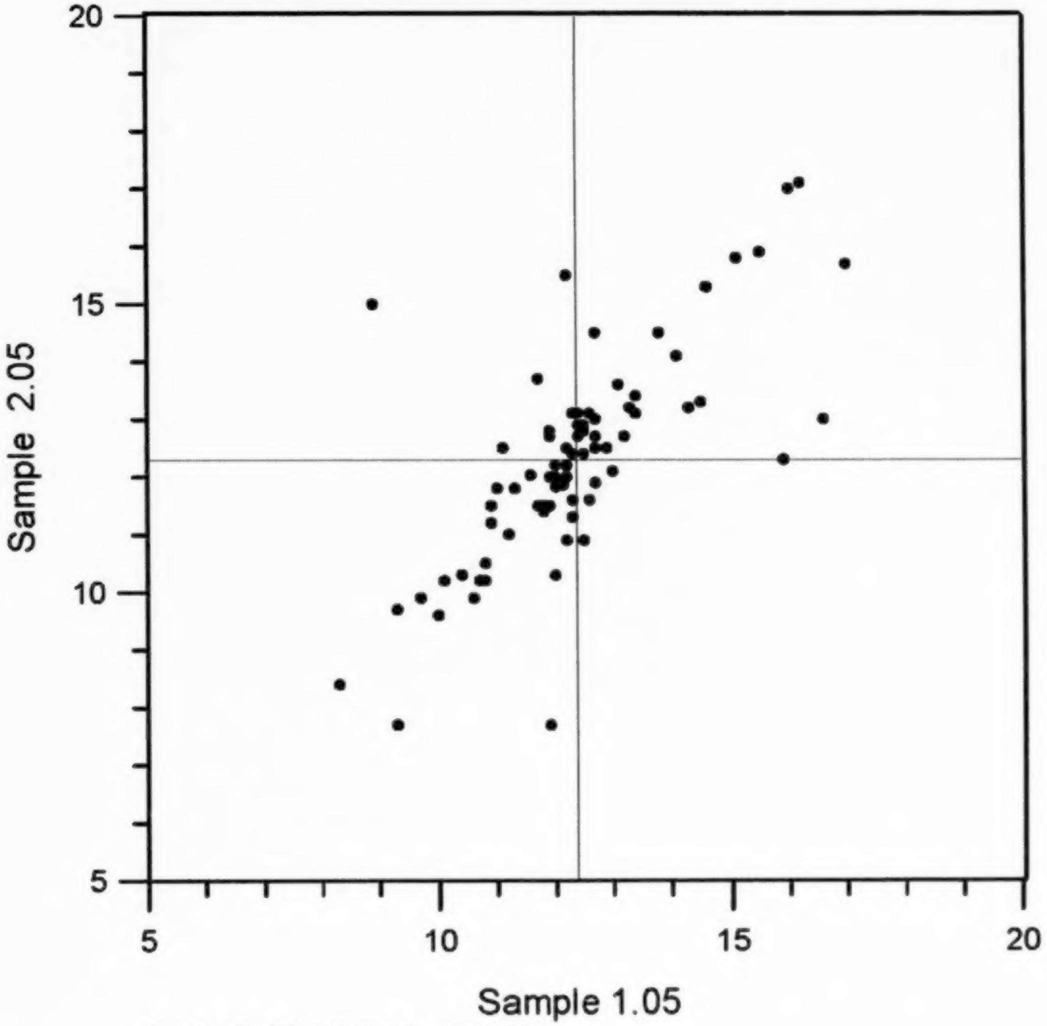
2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	15.578	15.537
Median	16.000	16.150
Std Dev	1.305	1.551
n = 75		

Labs eliminated: 108, 287

2005 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

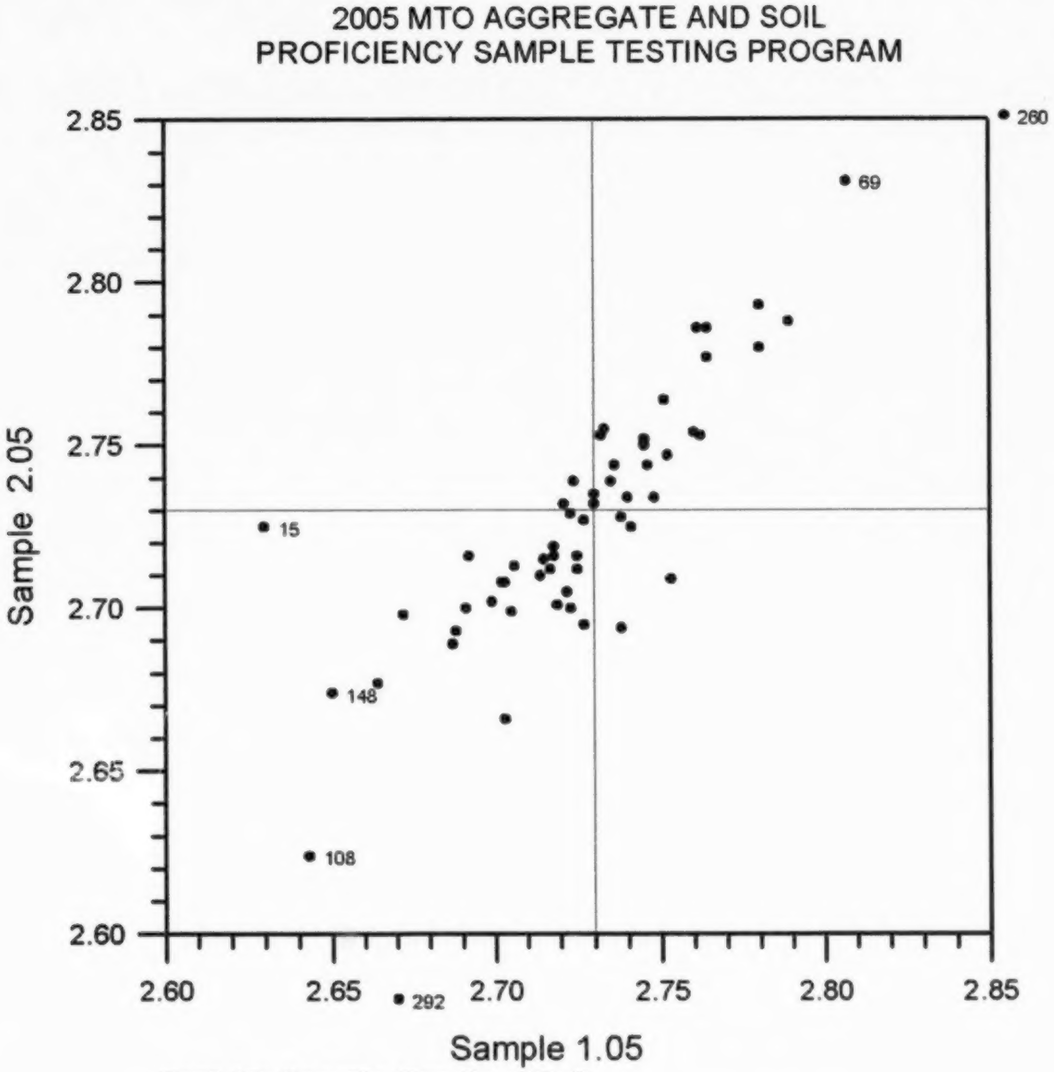


Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	12.331	12.294
Median	12.650	12.400
Std Dev	1.683	1.835

n = 77

Lab eliminated: None

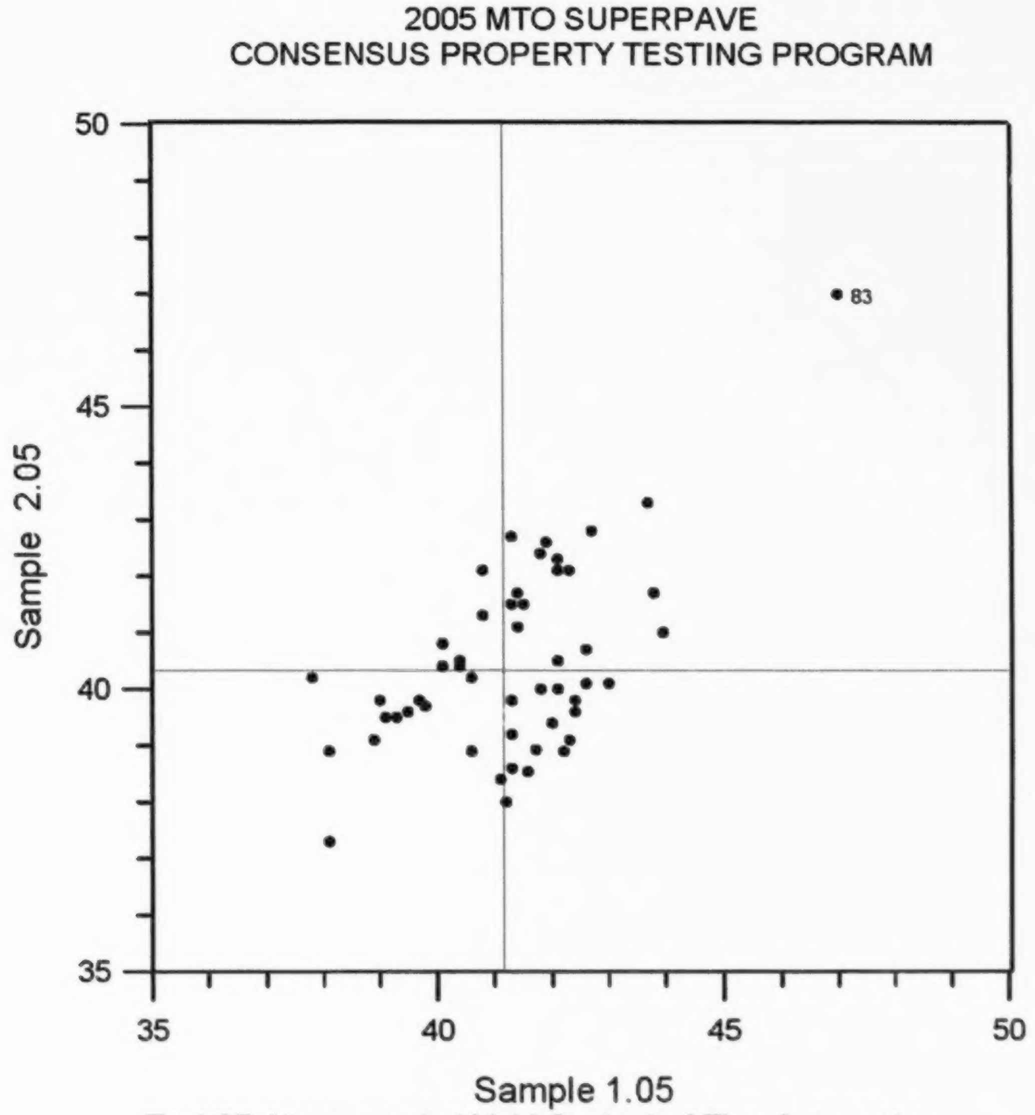


Test 49: Specific Gravity of Soil

	Mat 1	Mat 2
Mean	2.729	2.728
Median	2.727	2.730
Std Dev	0.027	0.030
n = 52		

Labs Eliminated: 15, 69, 108, 148, 260, 292

Appendix D2: Scatter Diagrams

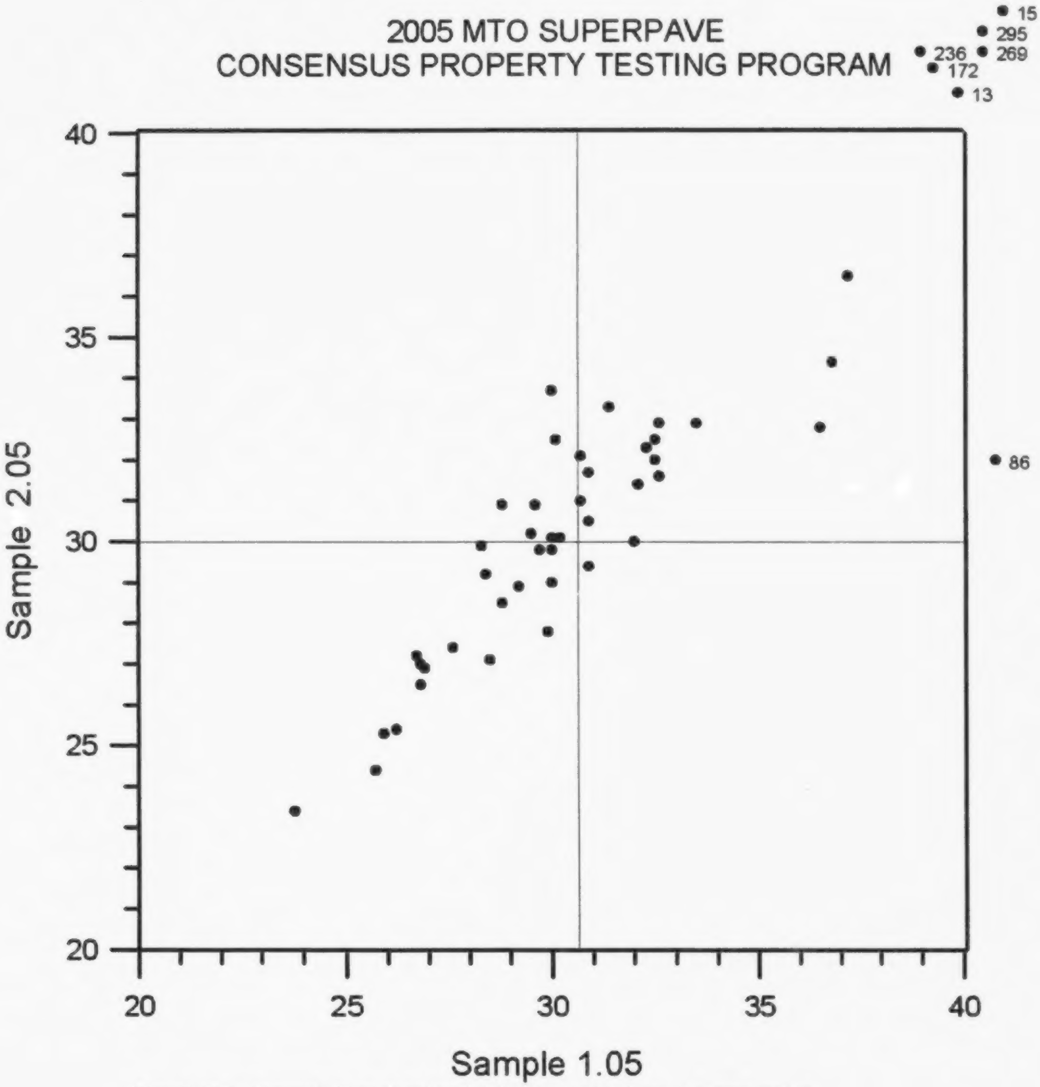


Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	41.187	40.329
Median	40.880	40.300
Std Dev	1.448	1.387

n = 50

Labs eliminated: 83



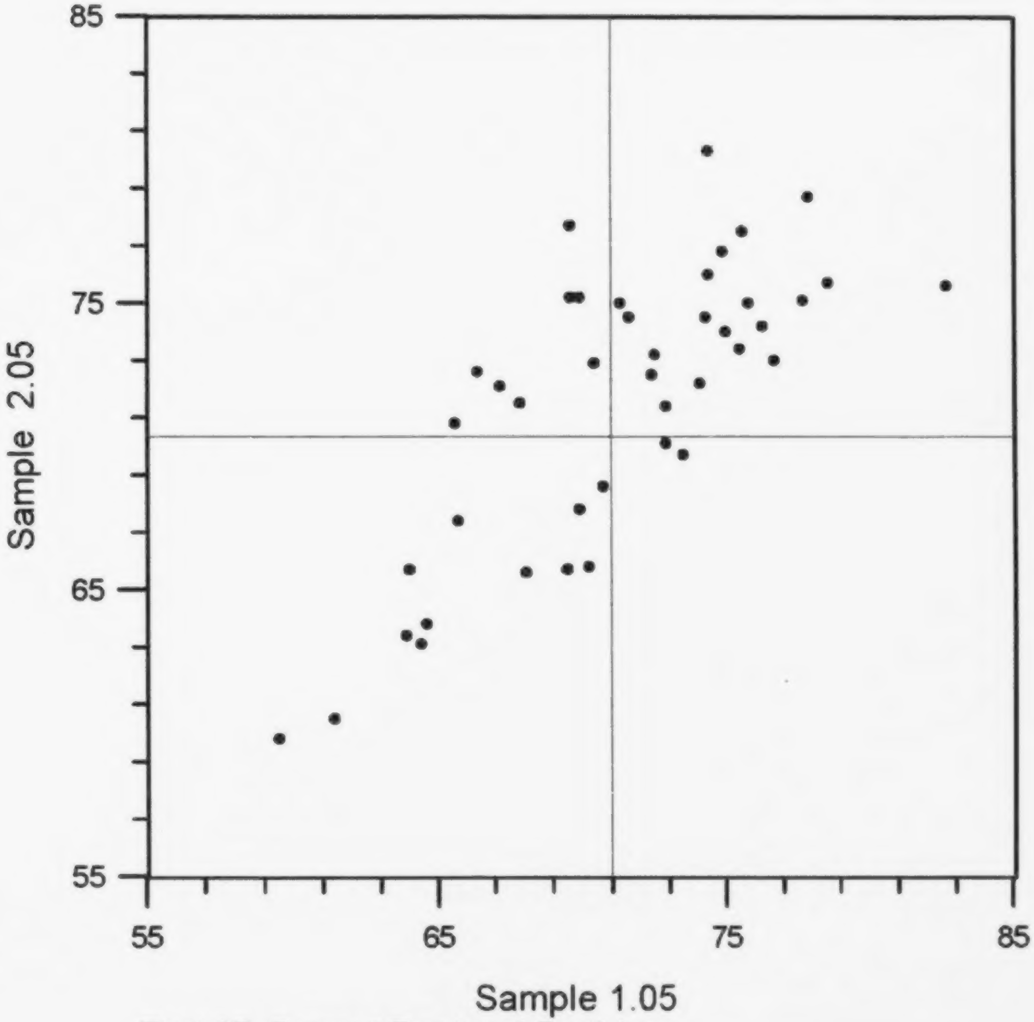
Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	30.738	30.028
Median	30.500	29.950
Std Dev	3.737	2.819

n = 42

Labs eliminated: 13, 15, 86, 172, 236, 269, 295

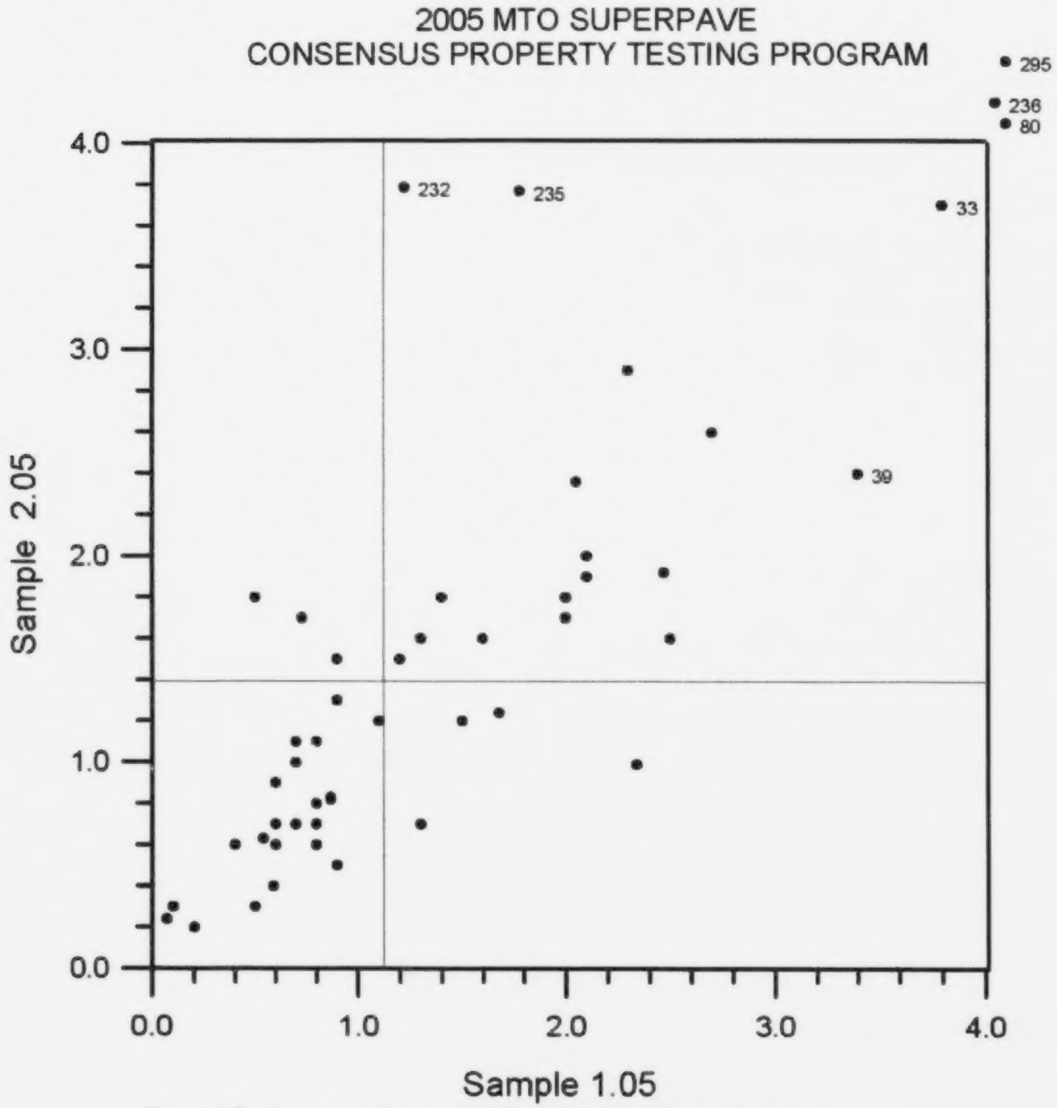
2005 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	71.286	70.538
Median	70.900	71.000
Std Dev	5.025	5.239
n = 53		

Labs Eliminated: None



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	1.142	1.179
Median	1.385	1.550
Std Dev	0.690	0.671
n = 46		

Labs Eliminated: 33, 39, 80, 232, 235, 236, 295

Appendix E1: Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
10	9	28.6	10	9		**94**
12	10	27.0	10	10	10	**96**
13	10	28.6	10	10	10	**98**
15	10	24.5	10	10	10	**92**
16	8	25.6	4	0	7	**64**
17	10	27.8	10	4	0	**74**
18	10	29.5	9	9	10	**96**
19	3	26.7	7	10	10	**81**
20	10	30.0	10	10	10	**100**
22	10	29.2	9	10	10	**97**
23	7	20.7	10	10	9	**81**
25	10	23.2	10	9	4	**80**
26	9	25.4	8	10	10	**89**
28	8	25.6	10	10	8	**88**
29	9	23.7	10	8		**85**
30	5	27.3	9	6	10	**82**
31	9	29.2	10	9	6	**90**
32	10	29.5	10	9	8	**95**
33	10	30.0	10	10	10	**100**
34	8	24.3	9	8	7	**80**
35	9	29.5	10	10	10	**98**
37	10	28.9	9	9	10	**96**
38	9	26.2	3	9	10	**82**
39	10	29.7	8	9	7	**91**
43	9	24.5	10	10	10	**91**
44	10	29.5	10	10		**99**
45	9	26.7	10	10	3	**84**
46	10	24.3	10	8	8	**86**
47	10	29.2	7	10	9	**93**
54	10	30.0	10	10	10	**100**
56	6	28.1	8	8	8	**83**
58	9	24.5	10	10	10	**91**
59	10	26.5	10	10	10	**95**
61	10	30.0	10	5	10	**93**
64	10	28.6	10	10	8	**95**
68	10	28.9	10	10	10	**98**
69	7	28.1	8	9	10	**89**
71	0	27.8	10	0	8	**65**
72	10	22.6	8	4		**74**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
73	10	30.0	6	0	10	**80**
79	10	27.5	10	10	10	**96**
80	7	26.2	10	10	10	**90**
81	10	27.3	10	7		**90**
83	10	29.2	8	8	10	**93**
85	9	24.5	10	10		**89**
86	9	29.7	10	10	10	**98**
90	10	28.9	10	10	9	**97**
94	10	24.5	4	10	3	**74**
98	10	26.7	10	9	0	**80**
100	10	29.2	10	10	10	**99**
101	4	29.7	10	9	7	**85**
102	10	17.2	9	9	10	**79**
103	10	27.3	1	10	8	**80**
104	9	23.5	10	10	10	**89**
107	9	27.3	7	10	10	**90**
108	10	24.3	10	9	10	**90**
110	2	17.7	8	10	10	**68**
112	8	27.3	10	10	10	**93**
113	10	24.0	10	9	7	**86**
115	10	26.5	10	9	10	**94**
116	10	27.3	8	0	10	**79**
117	7	22.6	8	10	10	**82**
120	8	27.3	10	4	8	**82**
123	10	24.8	10	10	10	**93**
124	10	29.2	10	10	10	**99**
126	9	27.8	10	6		**88**
127	10	28.6	8	9		**93**
128	10	27.5	8	9		**91**
129	10	28.6	10	7		**93**
134	10	30.0	10	9	10	**99**
135	10	28.1	10	9	10	**96**
136	9	26.7	10	9	10	**92**
137	10	26.5	10	10	10	**95**
138	10	29.5	10	9	10	**98**
139	1	24.8	10	9		**75**
141	10	26.5	9	4		**82**
144	10	14.5	10	7	10	**74**
146	10	27.0	10	8	10	**93**
147	8	19.6	7	4		**64**
148	10	30.0	9	9	10	**97**
153	10	26.7	9	10		**93**
157	10	30.0	10	10	8	**97**
158	10	29.5	10	7	8	**92**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
161	10	17.7	10	9	10	**81**
163	0	30.0	10	8	10	**83**
164	1	29.7	10	8	10	**84**
167	3	22.9	10	10	10	**80**
169	1	20.5	0	10	5	**52**
171	9	29.2	10	10	10	**97**
172	10	15.3	10	9	10	**78**
175	10	28.6	10	9	9	**95**
176	10	27.3	10	9		**94**
177	10	26.7	10	10	10	**95**
178	10	24.0	10	9	9	**89**
179	8	29.2	10	10	10	**96**
180	9	30.0	10	8	10	**96**
181	10	30.0	0	9	10	**84**
182	10	27.3	10	10	9	**95**
184	10	29.2	9	10	7	**93**
186	7	22.1	9	10	10	**83**
187	10	26.7	10	9	3	**84**
188	10	26.7	8	9	10	**91**
189	6	27.0	10	10	9	**89**
191	10	29.5	6	2	10	**82**
193	10	28.1	10	10	10	**97**
194	0	24.3	9	6	10	**70**
199	10	28.6	10	10	10	**98**
200	9	28.1	10	10	0	**82**
201	2	26.5	10	10		**81**
202	6	29.7	10	10		**93**
204	10	27.3	9	10	7	**90**
205	9	27.3	10	8	9	**90**
208	10	26.5	9	10	5	**86**
210	9	30.0	10	0		**82**
212	10	28.1	10	10	9	**96**
214	10	28.6	8	4	8	**84**
215	6	29.2	10	10	10	**93**
216	10	27.0	10	10	8	**93**
217	10	27.5	10	10		**96**
218	7	29.5	7	9	6	**84**
219	10	29.2	8	0	10	**82**
221	10	28.6	10	4	10	**89**
223	10	30.0	10	7		**95**
224	10	25.4	10	10	10	**93**
228	10	27.8	10	10	10	**97**
230	10	29.7	10	10	10	**100**
232	10	29.5	10	10	7	**95**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
234	7	29.7	6	8	10	**87**
235	10	28.9	10	10	7	**94**
236	10	26.7	10	0	6	**75**
242	10	27.5	10	9	9	**94**
245	7	29.2	7	5	5	**76**
246	10	28.4	10	8	10	**95**
247	10	23.2	8	9		**84**
248	9	26.2	9	10	10	**92**
249	9	28.1	9	10	5	**87**
250	9	28.4	8	8		**89**
251	10	27.0	7	8	10	**89**
252	0	29.7	10	10		**83**
253	10	30.0	10	9	10	**99**
254	10	30.0	9	10	9	**97**
255	10	29.7	8	9	10	**95**
256	10	28.4	10	4	10	**89**
257	10	29.5	3	9		**86**
258	8	25.1	10	9	10	**89**
259	10	28.9	5	8	9	**87**
260	10	21.0	10	9	10	**86**
262	2	25.4	10	10	2	**71**
263	10	29.5	8	10	10	**96**
264	8	28.9	10	5	8	**86**
269	10	23.5	10	7	8	**84**
271	10	23.2	5	7	10	**79**
272	10	26.5	8	10	8	**89**
273	10	30.0	6	10	8	**91**
274	10	27.8	10	9	10	**95**
275	9	25.9	10	8	5	**83**
276	10	29.5	10	10	10	**99**
277	10	28.9	10	10	10	**98**
278	10	28.6	6	10	8	**89**
279	10	27.0	10	9	10	**94**
280	1	27.5	0	9	9	**66**
284	10	28.1	9	10	10	**96**
285	9	16.4	8	9	10	**75**
287	9	25.6	10	9		**89**
288	0	28.4	8	9	10	**79**
290	10	27.0	10	2	8	**81**
291	10	27.3	7	2	0	**66**
293	10	28.9	10	7	10	**94**
294	10	28.4	9	9	10	**95**
295	10	26.2	10	10	9	**93**
297	10	29.7	10	10	9	**98**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
299	10	29.5	8	10	10	**96**
300	10	18.3	10	9	10	**82**
301	10	19.4	10	9	9	**82**
302	5	29.2	10	10	9	**90**
303	9	29.5	2	9	0	**71**
304	10	29.5	10	0		**82**
305	9	25.9	3	10		**80**
306	10	28.6	8	10	10	**95**
308	10	29.5	10		9	**97**
309	10	30.0	3	10	10	**90**
311	10	27.5	10	10		**96**
312	10	29.2	10	9	10	**97**
313	10	24.3	10	8		**87**
314	9	28.9	10	9		**95**
315	8	21.3	10	10	10	**85**
316	10	27.0	9	8	10	**91**
317	10	25.9	10	3	10	**84**
318	10	23.2	10	10	10	**90**
319	10	29.7	10	10		**100**
320	10	20.5	9	10		**82**
321	10	29.5	10	10	10	**99**
322	9	26.2	10	10		**92**
323	10	25.6	10	8	10	**91**
324	5	29.5	7	10	9	**86**
325	10	28.6	8	9	10	**94**
326	10	27.0	10	10	10	**96**
327	10	29.5	10	10	10	**99**
330	10	29.5	2	8		**82**
331	9	30.0	9	10		**97**

Appendix E2: Full Service Aggregate Laboratory Ratings

FULL SERVICE AGGREGATE LABORATORY RATINGS 2005

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 MgSO₄ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 MgSO₄ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
13	10	28.6		10	10	10	10	10	10	9	8	8	8.3	10	**95**
15	10	24.5		7	9	10	10	10	9	10	10	9	6.7	9	**89**
18	10	29.5		10	10	9	9	10	10	10	9	7	10.0	10	**96**
19	3	26.7		9.5		7	10	10	10	8	9.5		10.0	9	**87**
22	10	29.2		10		9	10	10	10	10	10		9.3	10	**98**
23	7	20.7		9.5	9	10	10	9	9	9	9	10	7.3	10	**86**
28	8	25.6		9		10	10	8	10	10	4		10.0	10	**88**
31	9	29.2	8	9	7	10	9	6	0	7	8.0	10	10.0	10	**83**
35	9	29.5	8	10	10	10	10	10	9	5	10	8	10.0	10	**93**
37	10	28.9	8	10	10	9	9	10	8	10	10	9	10.0	10	**95**
38	9	26.2	7	10	10	3	9	10	10	8	10	10	9.0	7	**86**
46	10	24.3		9.5	6	10	8	8	9	9	9.5	0	3.3	2	**72**
47	10	29.2	10	10		7	10	9	9	10	10		10.0	10	**96**
56	6	28.1	10	10	10	8	8	8	8	10	10	10	10.0	10	**91**
59	10	26.5		10	10	10	10	10	10	10	10	10	10.0	10	**98**
61	10	30.0		9.5		10	5	10	10	4	8		10.0	10	**90**
69	7	28.1		10		8	9	10	5	1	8.5		10.0	8	**80**
79	10	27.5		10		10	10	10	9	10	10		10.0	4	**93**
80	7	26.2	10	7	10	10	10	10	10	9	9.5	10	8.0	10	**92**
83	10	29.2		7.5		8	8	10	10	10	9.5		7.3	10	**92**
86	9	29.7		9.5		10	10	10	9	6	10		10.0	8	**93**
98	10	26.7		10	0	10	9	0	6	3	1.5	10	0.0	0	**57**
100	10	29.2		9	10	10	10	10	10	8	9.5			10	**97**
101	4	29.7	10	10	10	10	9	7	10	5	9.5	10	10.0	10	**90**
107	9	27.3		8	10	7	10	10	10	10	8.5	10		8	**91**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 MgSO₄ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 MgSO₄ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
110	2	17.7		10		8	10	10	10	10	7			7	**76**
112	8	27.3		10	5	10	10	10	10	10	10	9	10.0	9	**92**
123	10	24.8		10	10	10	10	10	0	0	8	10	7.7	3	**76**
124	10	29.2		10		10	10	10	10	10	10		10.0	10	**99**
157	10	30.0		5.5	10	10	10	8	10	10	9	10		9	**94**
164	1	29.7		9.5	10	10	8	10	10	10	10	9		10	**91**
172	10	15.3		9	10	10	9	10	9	10	8.5	10	10.0	8	**86**
177	10	26.7		9		10	10	10	10	9	10		10.0	10	**96**
188	10	26.7	10	10	10	8	9	10	10	10	10	8	10.0	10	**95**
199	10	28.6		9.5		10	10	10	10	10	10		10.0	10	**99**
205	9	27.3		10		10	8	9	10	10	9.5		9.3	10	**94**
214	10	28.6		10		8	4	8	9	4	9.5			10	**84**
216	10	27.0		9	9	10	10	8	10	9	10	10	10.0	10	**95**
245	7	29.2		10		7	5	5	10	9	10		9.0	10	**86**
260	10	21.0		7.5	10	10	9	10	9	8	8.5	3	10.0	10	**84**
263	10	29.5		10	8	8	10	10	10	10	8	10	10.0	8	**94**
285	9	16.4		9	10	8	9	10	10	10	10		9.3	9	**85**
295	10	26.2		10	10	10	10	9	10	10	7.5	8	10.0	10	**94**
301	10	19.4		9	10	10	9	9	10	10	10	10	9.3	10	**90**
306	10	28.6		9.5		8	10	10	10	10	10		9.3	8	**95**
316	10	27.0		10	6	9	8	10	9	10	8	9	10.0	10	**91**
325	10	28.6		10		8	9	10	5	10	8.5		10.0	9	**91**

Appendix E3: Soil Laboratory Ratings

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
12	9.6	6.7	7	**78**
15	7.4	7.3	5	**66**
18	9.2	9.3	10	**95**
19	9.6	10.0	9	**95**
20	7.4	8.3	10	**86**
22	7.0	8.7	10	**86**
23	9.6	7.0	7	**79**
28	8.6	9.3	10	**93**
29	10.0	9.7	9	**96**
30	8.6	10.0	10	**95**
31	5.4	10.0	10	**85**
32	9.6	7.3	7	**80**
34	5.6	7.7	5	**61**
35	8.6	9.3	10	**93**
37	9.6	10.0	10	**99**
38	9.6	10.0	9	**95**
44	10.0	7.0	9	**87**
47	10.0	10.0	4	**80**
54	7.2	10.0	10	**91**
56	9.6	10.0	5	**82**
58	8.6	10.0	10	**95**
59	9.8	9.7	10	**98**
64	8.8	8.0	7	**79**
68	7.8	10.0	10	**93**
69	8.0	10.0	0	**60**
71	8.8	10.0	7	**86**
72	9.8	10.0	10	**99**
79	9.6	10.0	10	**99**
80	8.8	10.0	9	**93**
83	9.4	9.0	10	**95**
86	9.0	9.3	10	**94**
94	9.4	10.0	10	**98**
98	8.0	9.3	6	**78**
101	9.8	10.0	10	**99**
102	8.6	9.7	10	**94**
108	4.4	3.7	0	**27**
112	7.6	9.7	9	**88**
120	9.4	9.7	9	**94**
138	9.6	7.3	10	**90**
146	10.0	9.3	10	**98**
148	8.6	8.0	0	**55**
172	9.6	5.0	10	**82**
188	8.8	9.3	10	**94**
208	9.6	10.0	6	**85**
210	9.2	8.3	10	**92**
216	6.6	10.0	10	**89**
253	7.2	8.7	7	**76**
260	8.8	10.0	0	**63**
276	10.0	7.7	10	**92**
284	8.8	9.7	10	**95**
285	9.2	9.7	10	**96**
292	10.0	9.0	0	**63**
299	6.4	9.7	10	**87**
300	8.2	9.3	10	**92**
301	6.2	10.0	10	**87**
306	7.2	8.7	9	**83**

Appendix E4: Superpave Laboratory Ratings

Laboratory No.	C 1252/T304 Uncompacted Void Content	D 2419/T176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
13	10	2	6	8	65
15	10	0	10	10	75
18	8	7	10	10	88
19	10	9	8	9	90
22	10	10	10	10	100
26	9	10	9	10	95
28	5	10	10	9	85
31	7	6	10	7	75
33	10	9	10	0	73
35	9	10	10	10	98
37	10	9	8	10	93
39	9	10	7	3	73
43	9	8	10	9	90
47	10	10	9	4	83
58	9	7	10	10	90
59	10	10	9	10	98
61	8	10	9	7	85
69	10	10	10	9	98
71	8	5	6	10	73
79	9	10	10	10	98
80	10	10	4	0	60
83	0	9	7	10	65
86	8	5	10	10	83
100	9	8	10	10	93
112	10	10	3	4	68
120	10	10	10	10	100
123	4	10	8	10	80
124	10	7	10	10	93
157	8	10	10	10	95
172	8	2	10	10	75
181	9	8	10	9	90
186	9	10	10	10	98

Laboratory No.	C 1252/T304 Uncompacted Void Content	D 2419/T176 Sand Equivalent	ASTM D 5821 % Fractured Particles	ASTM D 4719 % Flat & Elongated	Rating
188	10	10	10	8	**95**
189	6	10	10	8	**85**
199	10	10	10	10	**100**
216	10	10	10	8	**95**
232	9	10	10	5	**85**
235	9	9	10	5	**83**
236	9	0	10	0	**48**
245	10	10	10	8	**95**
263	9	8	10	10	**93**
269	10	0	9	10	**73**
271	10	5	10	10	**88**
272	9	10	8	10	**93**
285	9	10	7	7	**83**
294	10	10	10	10	**100**
295	9	1	6	0	**40**
316	8	8	9	10	**88**
325	7	10	10	7	**85**